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Spatial disaggregation of biodiversity footprints

A focus on urban vs rural consumption patterns

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MASTER THESIS

for

Student Maximilian Koslowski

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Spatial disaggregation of biodiversity footprints – A focus on urban vs rural consumption patterns

Romlig oppdeling av biodiversitetsfotspor - Et fokus på urbane og landlige forbruksmønstre

Background and objective

Biodiversity threats, such as deforestation, climate change, and pollution, can be linked to export-intensive industries like coffee growing or beef production (Lenzen et al., 2012; Moran & Kanemoto, 2017). While the production of respective goods is a direct domestic driver for related biodiversity losses, the demand for them lies often in other regions of the world (among others: Lenzen et al., 2012; Verones et al., 2017; Wilting et al., 2017). Biodiversity "footprints" show the relationship between consumption in a certain place and the impact on biodiversity both locally and abroad. With increasing urban consolidation, it is becoming increasingly clear that at the per-capita level, the major component of biodiversity footprints is driven by consumption of goods and services.

While recent studies have examined the urban vs rural dimension of carbon footprints and have identified both regional and subnational differences (e.g. Chancel & Piketty, 2015; Jones & Kammen, 2013; Moran et al., in preparation; Wiedmann et al., 2015), no such differentiation is available for biodiversity footprints. An additional challenge regarding both carbon and biodiversity footprints remains in bringing top-down approaches based on multiregional Input-Output (MRIO) analysis to the same level of detail as bottom-up approaches based on local survey data.

Therefore, the aim of this thesis is to contribute to closing the research gap of calculating spatially explicit consumption-based biodiversity footprints that allow the identification of subnational differences, with a focus on differences between urban and rural sites. The analysis will be done using an MRIO model.

The following tasks are to be considered:

1. Conduct a literature review on urban vs rural environmental footprints, as well as spatially explicit footprinting methods with a focus on biodiversity footprinting.
2. Disaggregate the household consumption section of the final demand vector into an urban and rural component. Include a number of socio-economic variables, at least identifying the population and household split in conjunction with the consumption data.

3. Compute spatially explicit biodiversity footprints, differentiating the impacts due to urban and rural populations. Analyse how different levels of urbanisation affect the impacts of embodied biodiversity impacts.
4. Analyse and discuss the results.

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Within 14 days of receiving the written text on the master thesis, the candidate shall submit a research plan for his project to the department.

When the thesis is evaluated, emphasis is put on processing of the results, and that they are presented in tabular and/or graphic form in a clear manner, and that they are analyzed carefully.

The thesis should be formulated as a research report with summary both in English and Norwegian, conclusion, literature references, table of contents etc. During the preparation of the text, the candidate should make an effort to produce a well-structured and easily readable report. In order to ease the evaluation of the thesis, it is important that the cross-references are correct. In the making of the report, strong emphasis should be placed on both a thorough discussion of the results and an orderly presentation.

The candidate is requested to initiate and keep close contact with his/her academic supervisor(s) throughout the working period. The candidate must follow the rules and regulations of NTNU as well as passive directions given by the Department of Energy and Process Engineering.

Risk assessment of the candidate's work shall be carried out according to the department's procedures. The risk assessment must be documented and included as part of the final report. Events related to the candidate's work adversely affecting the health, safety or security, must be documented and included as part of the final report. If the documentation on risk assessment represents a large number of pages, the full version is to be submitted electronically to the supervisor and an excerpt is included in the report.

Pursuant to “Regulations concerning the supplementary provisions to the technology study program/Master of Science” at NTNU §20, the Department reserves the permission to utilize all the results and data for teaching and research purposes as well as in future publications.

The final report is to be submitted digitally in DAIM. An executive summary of the thesis including title, student’s name, supervisor's name, year, department name, and NTNU's logo and name, shall be submitted to the department as a separate pdf file. Based on an agreement with the supervisor, the final report and other material and documents may be given to the supervisor in digital format.

☐ Work to be done in lab (Water power lab, Fluids engineering lab, Thermal engineering lab)
☐ Field work

Department of Energy and Process Engineering, 22 February 2018

Richard Wood
Academic Supervisor

Disclaimer

The thesis objectives and tasks mention spatially explicit biodiversity footprints. This wording may be misunderstood; in agreement with the supervisors from the very beginning on, country-specific biodiversity footprints disaggregated by various socio-economic variables were to be quantified, thus being on a virtual sub-national level. The spatially explicit aspect herein is the use of spatially differentiated characterisation factors from life cycle impact assessment methodologies.

Preface

This thesis was carried out at the Industrial Ecology programme at NTNU. The work was conducted during the spring semester of 2018 and is, in agreement with my supervisors, written in the style of a research article. That is, a publication of it is aimed for. Therefore, the main section of it was kept concise, whereas precise details on a literature overview, methods, and results are extensively elaborated on in the supporting information.

Apart from the main author, several people were involved in this work, the contribution of which shall be briefly outlined here. Richard Wood gave in his function as main supervisor general guidance, helped elucidating deeper aspects of the topic as ideas for additional examination, and made valuable comments for finalising the thesis. Daniel Moran was co-supervising the work, clarified steps in the MRIO footprint calculations, and helped to overcome methodological difficulties. Alexandre Tisserant provided close co-supervision on reconciling data from consumer expenditure surveys and the subsequent disaggregation of household final demand. Code written by Alexandre on reconciling and disaggregating final demand by income quintiles served as general guideline for this part; however, due to the nature of data, data availability, and topic and scope of the project, entirely new code had to be written. Alexandre provided, moreover, the required EXIOBASE v3.4 data. Details on code and relevant files can be found in the supporting information (SI13). The procedure of reconciling consumer expenditure survey data was thereby largely based on the approach by Steen-Olsen et al. (2016) and its further form by Ivanova et al. (2017). Francesca Verones provided detailed guidance on the general principle of deriving country-specific characterisation factors from spatially explicit data sources and was available for discussions on the underlying impact assessment methodology. In addition, Francesca made LC-Impact raster files of emissions and resource uses available that were not included on the respective website. With the urban-rural split of household final demand being the initial main aspect of this thesis, the idea for assessing not only environmental pressures but impacts was mutual between the author and Daniel Moran, and is to a large extent based on previous work by Verones, Moran, et al. (2017). Figure 6 would not have been possible without the contribution of Martin Dorber.

Because of this diverse, and partly detailed, support of the above-mentioned persons, this thesis/paper is written in the "we" narrative, when a passive form could not be avoided. The independent character of the thesis was, however, tried to be preserved. All the persons listed above were affiliated with the Industrial Ecology programme at NTNU, Trondheim at the time this thesis/paper was produced.

Acknowledgements

This thesis is the final part of my master's degree at the Industrial Ecology programme at NTNU. It has been a wonderful experience, and on my way till here I was supported by many people.

I want to thank my supervisors Richard Wood, Daniel Moran, and Alexandre Tisserant for their helpful guidance, valuable comments, and additional assistance. Especially Alexandre was always available for discussions on the topic, but also for quick chats on life.

I would like to extend my gratitude to Francesca Verones – who had, over the course of the last two years, always been there for me with advice and support, and even co-supervised some part of this thesis. Her mentorship strongly influenced my study direction and made me feel comfortable in the programme even when sometimes not everything was going as planned.

To my friends and classmates at IndEcol: Together we laughed, suffered, philosophised, and enjoyed life. Without you, the last years would have been entirely different. Thank you all for our time together!

Finally, a huge thank you goes to all closest to me, both here in Norway and abroad. To my friends. To my family. To my *Mama* – I wish you could read this.

Abstract

Biodiversity is threatened by diverse pressures. Deforestation, climate change, water stress and other factors contribute to its gradual degradation. Apart from negligible natural sources, main drivers of this development are the consumption and production of goods and services, both domestically and abroad. Modern society, particularly in affluent countries, increases the pressure on the environment via unsustainable lifestyle choices and a lack of appropriate policy responses. An understanding of the influence of socio-economic variables such as urbanisation, income distribution, and household size is therefore important. In this study, we examined the role of selected socio-economic variables regarding environmental impacts associated with European household consumption in the years 2005 and 2010. We applied a multi-regional input-output model, extended by the life cycle impact assessment methodologies LC-Impact and ReCiPe to account for biodiversity losses. The required trade data from EXIOBASE v3.4 was ameliorated with consumer expenditure survey data from Eurostat to allow for the disaggregation of household final demand. We find that urbanity and higher income are sources of higher absolute biodiversity footprints. On the per capita level, the allocation of impacts to the differing degrees of urbanisation is more even and country dependent, although city residents are still slightly more culpable in most countries. The role of income only changes over the years, but not so much across countries. While absolute biodiversity footprints for both reference years as well as 2010 per capita footprints were shown to increase with higher income, 2005 per capita footprints revealed no distinct pattern. The major contributor to reductions in species richness was found to be land use, which was mainly driven by the demand for agricultural products. Most European countries and Europe as a whole were identified as net-importers of biodiversity losses.

Sammendrag

Biodiversitet er truet av ulike miljøpåvirkninger. Avskoging, klimaendringer, overforbruk av vann og andre faktorer bidrar gradvis til tap av biologisk mangfold. Bortsett fra ubetydelige naturlige årsaker er forbruk og produksjon av varer og tjenester, både i inn-og utland, hoveddriverne i denne utviklingen. Det moderne samfunnet, særlig velstående land, øker belastningen på miljøet som følge av et levesett som ikke er bærekraftige og mangel på hensiktsmessige politiske tiltak. Det er derfor viktig å ha en forståelse av påvirkningen fra sosioøkonomiske variabler som urbanisering, inntektsfordeling og husholdningsstørrelse. I denne studien undersøkte vi utvalgte sosioøkonomiske variabler sin betydning på miljøpåvirkningen fra forbruket til europeiske husholdninger i årene 2005 og 2010. Vi benyttet en multiregional input-output modell, utvidet med livsløpseffektvurderinger ved bruk av metodene LC-Impact og ReCiPe, for å ta hensyn til tap av biologisk mangfold. For å kunne dele husholdningsforbruket inn i kategorier ble de nødvendige handelsdataene fra EXIOBASE v3.4 kombinert med data fra Eurostats undersøkelser om forbrukerutgifter. Resultatene viser at urbanitet og høye inntekter har en større absolutt påvirkning på biodiversitet. På innbyggernivå er påvirkning fra de ulike nivåene av urbanisering mer jevnt fordelt og landsavhengig, selv om innbyggere i byer i de fleste land fortsatt har en større innvirkning på det biologiske mangfoldet. Hvor stor innvirkning inntekter har endres bare gjennom årene, men ikke så mye på tvers av land. Mens det viste seg at det totale tapet av biologisk mangfold for begge referanseårene og per innbygger i 2010 økte med høyere inntekter, var det ikke et tydelig mønster å finne per innbygger i 2005. Studien viser at den største bidragsyteren til reduksjon i artsmangfold er arealbruk, som hovedsakelig var drevet av etterspørselen etter landbruksprodukter. De fleste europeiske land og Europa som helhet ble identifisert som netto importører av tap av biologisk mangfold.

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List of abbreviations

CES	Consumer expenditure survey
COICOP	Classification of Individual Consumption by Purpose
EU28	Current 28 member states of the European Union
GDP	Gross domestic product
LCIA	Life cycle impact assessment
LCA	Life cycle assessment
MRIO	Multi-regional input-output analysis
PDF	Potentially disappeared fraction of species

Heim kommt man nie. Aber wo befreundete Wege zusammen-
laufen, da sieht die ganze Welt für eine Stunde wie Heimat aus.

- Hermann Hesse, Demian

1 Introduction

Although biodiversity has already declined significantly in the past decades, projections of biodiversity loss drivers indicate even increasing future impacts (Millennium Ecosystem Assessment, 2005; WWF, 2016). The International Union for Conservation of Nature (IUCN) estimates that more than 25,000 species are presently threatened with extinction (IUCN, 2018). Moreover, with current extinction rates being about 1,000 times higher than the background rate (Pimm et al., 2014) and an already vanished 7% of known biodiversity (Régnier et al., 2015), one may ask whether the modern world has entered a sixth mass extinction event (Barnosky et al., 2011).

These threats to biodiversity are induced by multiple pressures. Deforestation, greenhouse gas emissions, over-fertilisation, and others cause environmental degradation via habitat loss, climate change, and alike (Millennium Ecosystem Assessment, 2005; WWF, 2016). While the production of goods like coffee or beef is a direct domestic driver for such environmental pressures, the demand for these goods often lies in other regions of the world (Lenzen, Moran, et al., 2012; Chaudhary & Kastner, 2016; Moran & Kanemoto, 2017; Verones, Moran, et al., 2017; Wilting et al., 2017; Wiedmann & Lenzen, 2018). Particularly European countries show high global pressures embodied in net-trade (Wood et al., 2018). And yet, the extent of a country's environmental burdens and associated impacts, and whether they occur domestically or abroad depends on its socio-economic structure (Ivanova et al., 2016; Wilting et al., 2017).

Appropriate political agreements safeguarding the environment, such as the United Nations Sustainable Development Goals (United Nations, 2015) or the Aichi biodiversity targets (Secretariat of the Convention on Biological Diversity, 2014), become pivotal to curb environmental pressures on a global scale and thus prevent extinction rates from increasing further. One can argue, however, whether these accords are addressing the actual causes of ecosystem damage (Barnes, 2015; Brown et al., 2015). Hence, to allow for adequate political responses to environmental degradation, detailed assessments of the reasons for species losses and where they occur are required.

It was shown earlier that particularly household consumption is a major component regarding environmental repercussions along global supply chains (Ivanova et al., 2016). Moreover, it can be expected that increasing urban consolidation provokes an intensification of the link between ecosystem damage and the consumption of goods and services. While the role of cities has been covered extensively with respect to greenhouse gas emissions, outlining both regional and subnational differences (Jones & Kammen, 2014; Kanemoto et al., 2014; Wiedmann et al., 2016; Moran et al., 2018), no such assessment is available to date for other pressures or actual impacts on biodiversity. In conjunction with urbanisation, also other socio-economic variables, such as income or household size, are expected (and were previously shown) to influence the environmental burden of household consumption (Weinzettel et al., 2013; Jones & Kammen, 2014; Steen-Olsen et al., 2016; Ivanova et al., 2017).

Hence, with modern lifestyles and globalisation being significant drivers of the above challenges, there is a strong need for their assessment. Economic top-down assessment methods commend themselves for further analysis of environmental burdens as well as their causes and origins via so-called footprints (see SI1 – 2), ideally under consideration of spatial differentiation (Godar et al., 2015). Footprints are mainly derived through consumption-based accounting following the Leontief demand-pull calculus (Leontief, 1936; 1970; see also SI6). The latter, commonly referred to as input-output analysis, links data on environmental burdens for all sectors of an economy with these sectors' monetary and/or physical transactions; increasing the spatial scope of such assessments, multi-regional input-output (MRIO) analyses are used. In addition, the MRIO model's detail of household final demand can be expanded through an extension with data from consumer expenditure surveys (CES). An extensive overview of the existing literature on environmental applications of MRIO can be found in SI2.

To not only account for pressures but impacts, the combination of consumption-based accounts and life cycle impact assessment (LCIA) methodologies allows for an enhanced representation of environmental consequences (Verones, Moran, et al., 2017). LCIA methods are the backbone of life cycle assessments (LCA) for estimating the impact of individual products and technologies. It must be noted, however, that an immanent discrepancy exists between traditional pressure footprints and impact footprints. Namely, pressures and impacts exchanged through international trade differ in both magnitude and relative contribution when spatially compared (Verones, Moran, et al., 2017). Hence, policies for environmental impact reduction may be misled by results from pressure footprint studies. The advancement of impact footprints on the sub-national level is therefore crucial for policy-making regarding the link between consumption and environmental protection. To the best of our knowledge, no approach exists that applies consumption-based accounts to elucidate the role of multiple socio-economic variables regarding biodiversity losses.

For these above reasons, here we assess the country-specific environmental pressures and impacts of European household consumption, using an MRIO model reconciled with CES data and extended with LCIA methodologies. Following the subsequent section on materials and methods, we present European biodiversity footprints on regional, national, and virtual sub-national levels, with a focus on urban vs rural consumption patterns. We outline the influence of selected socio-economic drivers, give detailed accounts of species losses embodied in trade, and describe the role of different product sectors and impact categories. In the final section, we discuss these results with regard to current socio-economic developments, highlight challenges as well as opportunities for future research on this topic, and provide some concluding remarks.

2 Materials and methods

We applied environmentally extended MRIO analysis to quantify global biodiversity losses due to emissions and resource uses along global and domestic supply chains induced by European household consumption of goods and services. In order to examine the role of different socio-economic variables, with a particular focus on urbanisation, the household final demand was disaggregated by supplementing the MRIO model with detailed data from CESs. Environmental emissions and resource uses *per se* were accounted for through pressure footprints, i.e. solely relying on available MRIO data, whereas actual biodiversity losses were characterised via an extension of the MRIO model with LCIA methods. The analyses were conducted for the years

2005 and 2010. A detailed description of applied materials and methods is provided below and in the respective sections of the supporting information.

2.1 Environmentally extended MRIO analysis

Various methods exist for analysing environmental impacts. Although bottom-up approaches such as LCA allow for comparatively higher detail, namely analyses on product or technology level, the top-down accounting method MRIO is preferable for national or regional assessments because of the complete coverage of supply chains and the avoidance of truncation errors (Majeau-Bettez et al., 2011; Wiedmann & Barrett, 2013; Steen-Olsen et al., 2016). MRIO analysis covers both inter-industry and final demand in multiple regions and their bilateral trade interlinkages. By including environmental extensions, MRIO can track environmental pressures associated with trade flows of goods and services.

MRIO in general and environmentally extended MRIO in particular trace back to the pioneering work of Wassily Leontief (1936, 1970) and have been described in their fundamentals extensively elsewhere (Miller & Blair, 2009; Kitzes, 2013).[1] MRIO uses information on emissions and resource uses within a nation (production-based account) in order to calculate the environmental burdens associated with the final demand of a nation (consumption-based account) (Wiebe & Yamano, 2016).[2] Both variations found numerous applications in previous studies for calculating footprints regarding environmental pressures, e.g. greenhouse gas emissions (Kanemoto et al., 2016; Wiedmann et al., 2016; Moran et al., 2018), land use (Ewing et al., 2012), material requirements (Wiedmann et al., 2015; Giljum et al., 2016; Tukker et al., 2016), water stress (Mekonnen & Hoekstra, 2011; Lenzen, Moran, Bhaduri, et al., 2013; Lutter et al., 2016), or threatened biodiversity (Lenzen, Moran, et al., 2012; Moran & Kanemoto, 2017).[3] For assessing the role of household final demand, consumption-based accounting is clearly more suitable, because it allows for the allocation of impacts embodied in a good or service to the place of consumption.

For our analytical MRIO model, we used data from the EXIOBASE v3.4 MRIO database (Tukker et al., 2013; Wood et al., 2015; Stadler et al., 2018) to calculate consumption-based accounts. EXIOBASE represents the world economy for the period 1995 – 2011, distinguishing between 28 EU member countries, 16 major economies, and five rest of the world (RoW) regions, each of the above with a sectoral detail of 163 industries by 200 products. Moreover, EXIOBASE includes an extensive environmental satellite account, covering a variety of emissions and resource uses (see section 2.4). The rationale for choosing EXIOBASE was twofold: first, it provides the highest sector resolution in comparison with other MRIO databases, and second (Table S1), its individual representation of European countries allowed for a satisfying CES-MRIO data fit.[4] Other MRIO databases exist, such as Eora (Lenzen, Kanemoto, et al., 2012; Lenzen, Moran, Kanemoto, et al., 2013), GTAP (Aguiar et al., 2016), or WIOD (Timmer

[1] See also SI2 for a description of a basic input-output model
[2] See SI1 for an introduction into both variations
[3] See SI2 for a detailed overview of MRIO applications
[4] See the section on consumer expenditure survey data reconciliation for more clarity on this point

et al., 2015), yet none of them offered similar advantages. An overview of these and other MRIO databases is provided in SI3.

The final demand in the present MRIO model consists of seven categories, including the consumption expenditure by households, gross fixed capital formation, and exports. CES data from Eurostat (2018b) was applied to further split the household final demand of 29 European countries (EU28 plus Norway), since this domain is of particular interest regarding societal changes and policy-making (Ivanova et al., 2017). CES data was available for a set of different socio-economic variables, according to all of which the household final demand was disaggregated. The different classifications per socio-economic variable are named parameters in the following, e.g. "cities" as one parameter of the variable "degrees of urbanisation". The standard partition form was by country and parameter, i.e. 29 countries times the number of parameters. Based on that, further aggregations, e.g. household final demand per parameter, and disaggregations, e.g. household final demand across all countries and sectors, were computed. Details on the disaggregation procedure and the preceding CES data reconciliation can be found in section 2.2, as well as in SI4 and SI5, respectively.

We calculated environmental footprints on four distinct levels for various transformations of the household final demand for all selected European countries and both reference years, applying the standard Leontief demand-pull model (Leontief, 1936, 1970). The levels are pressure, characterised pressure, and impact (two types). Whilst pressure footprints account for discernible emissions and resource uses associated with household final demand, characterised pressure footprints aggregate such emissions and resource uses into equivalents where applicable, e.g. CO_2 equivalents. More specifically: whereas pressure footprints account for individual pressures, such as carbon dioxide, methane, nitrous oxide, and others, characterised pressure footprints aggregate such pressures into groups, for instance, the above-mentioned greenhouse gases into CO_2 equivalents. Impact footprints relying on the ReCiPe impact assessment method (Huijbregts et al., 2016) continue from such characterised pressure footprints by bringing them through conversion factors from mid- to endpoint[5] levels, thus indicating environmental impacts, in this case biodiversity loss. In comparison, impact footprints based on the LC-Impact methodology (Verones et al., 2018) also account for biodiversity loss, however, they characterise raw emissions and resource uses directly into the latter without the need for an intermediate step of aggregating them. Details on the calculation methods for each footprint type can be found in SI6 and SI7. Details on the used impact assessment methodologies are provided in section 2.3.

2.2 Consumer expenditure survey data reconciliation

While the applied MRIO model in its original form provides information on household final demand per country, sourced from national accounts, no further disaggregation of it with respect to socio-economic variables is provided. Data from consumer expenditure surveys contain this information, so that complementing the MRIO model with CES data allows the analysis of

[5] Endpoint levels are increasingly referred to as damage levels (Verones, Bare, et al., 2017; Woods et al., 2017). Here, however, we use the term "endpoint" to align with the nomenclature used in the reports of the respective impact assessment methodologies.

household final demand on a virtual sub-national level for a multi-region (Steen-Olsen et al., 2016; Ivanova et al., 2017).

Various databases exist that provide CES data on a national or international level such as the ones by the US Bureau of Labor Statistics (2018), Eurostat (2018b), or the World Bank Group (2018). Although most of these databases cover similar socio-economic aspects, their definitions of such may differ – which impedes a global assessment, as CES data from multiple databases would have to be combined. With a focus on Europe, Eurostat (2018b) becomes the CES data source of choice.

Eurostat's CES data stems from annual large-scale household budget surveys conducted by National Statistical Institutes (Eurostat, 2018a). These have been run every 5-6 years since 1988 with 2010 being the newest comprehensive dataset available (Eurostat, 2015). Data for 2015 was also available, yet only for a few countries; therefore, and because no EXIOBASE MRIO data is available for this year, 2015 was excluded from the analysis. The year with the highest country-coverage is 2010, followed by 2005; hence, these two years were chosen as reference years.

The extension of the present MRIO model with CES data required several amelioration steps, the procedure of which followed to a large extent the approach taken by Steen-Olsen et al. (2016) and Ivanova et al. (2017), and is described in detail in SI4. Essential stages were the upscaling of country-specific mean consumption expenditure per household to the national level, structured by parameters and sectors according to the COICOP classification (United Nations Statistics Division, 2018);[6] the accounting for underreporting, i.e. including detail on the difference between household expenditures reported in CES and MRIO data (Bee et al., 2012; Steen-Olsen et al., 2016; Ivanova et al., 2017); and the COICOP-EXIOBASE sector bridging using country-specific, weighted concordance matrices. In the course of this adjustment, the valuation in purchaser prices had to be converted into basic prices, since the EXIOBASE stressor intensities are only linkable with final demand in basic prices.

CES data was structured according to various socio-economic variables. Multiple datasets per variable were required to suffice the CES data reconciliation approach. That is, only those socio-economic factors were considered for which all necessary data were available. This was the case for the variables degrees of urbanisation, income quintiles, age groups, and types of households. While degrees of urbanisation are the central point in this study for examining urban vs rural consumption patterns and associated environmental impacts, the other socio-economic variables were examined additionally to account for differences in lifestyle and wealth. Degrees of urbanisation distinguish between three parameters (cities/urban, towns/suburban, rural), based on population densities, whereas income is divided into quintiles (Table S3). Types of households describe the household size, i.e. the number of people living there. As the category of age groups is only accounting for the age of the main income earner per household, resulting

[6] COICOP is the acronym of "Classification of Individual Consumption according to Purpose" (United Nations Statistics Division, 2018)

footprints were deemed to be less relevant and are therefore only shown in the supporting information.

Although Eurostat (2018b) does not provide CES data on the selected socio-economic variables across *all* European countries for both reference years, the majority of them is covered (Tables S4 – S7). Concurrently, of all major MRIO databases, EXIOBASE provides the most detailed sectoral coverage of European countries. The CES-MRIO link is established through sector concordance matrices; due to the standardised sectoral detail in both frameworks, these concordance matrices are structurally stable, although they vary in their configuration across the respective countries. Both the European country coverage and the sector bridging describe the CES-MRIO fit mentioned earlier.

2.3 Impact assessment methods

Consumption-based biodiversity accounts were calculated via an extension of the complemented MRIO model with LCIA methods. LCIA methods are applied in LCA, which is used for assessing environmental impacts of a good or service throughout its life cycle. LCA is classified by four distinct stages (ISO, 2006a, 2006b): the definition of goal and scope of the study including functional unit; an inventory analysis (the collection of data on inputs, outputs, and emissions); the actual impact assessment, i.e. accounting for environmental impacts of the respective good or service via the combination of LCIA with the inventory; and an interpretation of the results. Although LCIA is inherent to process-based LCA, it was shown earlier that its characterisation factors can be used in MRIO-based environmental assessments (Verones, Moran, et al., 2017).

Of the existing LCIA methods, LC-Impact (Verones et al., 2018) and ReCiPe (Huijbregts et al., 2016) were chosen due to their level of detail and ability to expand the impact assessment to endpoint levels such as biodiversity losses via characterisation factors. These endpoint characterisation factors indicate the environmental impact per unit of stressor (Verones et al., 2018). In comparison, midpoint characterisation factors characterise stressors into midpoint impact categories, e.g. global warming potential, measured in emissions and resource use equivalents. Environmental impacts on endpoint level can affect various areas of protection, namely ecosystem well-being (sometimes also referred to as ecosystem quality), human health, and resources; both LC-Impact and ReCiPe are capable of accounting for all three of them. For the present analysis, however, only ecosystem well-being was considered, scilicet biodiversity losses associated with household final demand. The term biodiversity being ambiguous (Curran et al., 2011), it is species richness (or rather, losses of it) that the above impact assessment methods measure via distinct metrics.

Despite their similar applications and foundations, LC-Impact and ReCiPe differ considerably. While LC-Impact offers spatially explicit endpoint characterisation factors of fine granularity, ReCiPe provides only country-specific as well as weighted, globally-averaged endpoint characterisation factors. Moreover, LC-Impact accounts for global species losses and, for land and water stress, also for the vulnerability of species through corresponding scores, whereas ReCiPe only covers local species losses. The metrics used for measuring biodiversity loss are the potentially disappeared fraction of species over time (PDF.yr; LC-Impact) and the time-integrated number of species lost (species.yr; ReCiPe), respectively. As for the actual characterisation factors, these are given per emission or resource use, for instance, PDF.yr/m² for land use (Tables S10 – S13). Information on the coverage of impact categories is provided for the present case in the following section (2.4). In addition, both methods allow for value choices regarding uncertainty and robustness. More specifically, ReCiPe provides characterisation factors according to so-called cultural perspectives, which constitute different assumptions regarding time horizon, impact pathways, and other factors. In comparison, LC-Impact follows a modular approach through its core and extended characterisation factors, meaning the former is valid for a specified time horizon and high level of certainty, and the latter extends the time horizon by simultaneously reducing the level of certainty and varying in the coverage of impact pathways.

For calculating biodiversity impact footprints in the present analysis, spatially-explicit LC-Impact characterisation factors and weighted globally-averaged ReCiPe mid- to endpoint conversion factors were applied. Time constraints prevented the application of ReCiPe's country-specific characterisation factors. Regarding value choices, LC-Impact's core characterisation factors and ReCiPe's hierarchist perspective were applied.[7] More details on the applied impact assessment methods, as well as the preparation and derivation of characterisation factors can be found in SI9.

2.4 Accounts of emissions and resource uses

The environmental satellite account of EXIOBASE covers 1338 stressors of different domains and is given in intensities, i.e. as environmental loads in respective units per monetary unit; additionally, EXIOBASE includes a set of 215 characterisation factors, according to multiple methodologies, that allow for the derivation of stressor equivalents per monetary unit when multiplied by the stressor intensities (Tukker et al., 2013; Wood et al., 2015; Stadler et al., 2018). In the present study, multiple impact categories were considered, each of which relied on the aggregation of relevant stressors. The selection of impact categories, in turn, differed depending on the footprint type (SI8).

LC-Impact and pressure footprints comprise the impact categories land occupation, blue water consumption, global warming, photochemical ozone formation, freshwater eutrophication, and terrestrial acidification (Table S8). ReCiPe and characterised pressure footprints encompass land use, water consumption, global warming, terrestrial acidification, and toxicity (Table S9). Photochemical ozone formation was not assessed for ReCiPe footprints, although a mid- to endpoint conversion factor is available; this is due to the lack of corresponding midpoint characterisation factors in EXIOBASE. For a comparison of the footprints, only impact categories covered by all respective accounts were considered. While pressure accounts aggregate stressor intensities where applicable and are classified according to the above categories, LC-Impact

[7] Footprint results based on LC-Impact's extended characterisation factors are included in the corresponding Excel spreadsheet in the digital SI.

accounts convert these aggregated stressor intensities into endpoint intensities, i.e. environmental impacts per monetary unit, before the actual footprint calculation. For both pressure and LC-Impact footprints, the stressors were selected manually. In comparison, characterised pressure and ReCiPe footprints applied both the same selection of EXIOBASE midpoint characterisation factors to the stressor intensity matrix, thus retrieving emission and resource use equivalents per monetary unit; that is, no stressors had to be selected manually. In the case of ReCiPe footprints, the stressor equivalents per monetary unit were then multiplied by the corresponding mid- to endpoint conversion factors, thus yielding, similar to LC-Impact accounts, environmental impacts per monetary unit.

Depending on the footprint type, the derived stressor aggregations or environmental multipliers were then multiplied by the Leontief inverse and the disaggregated, complemented final demand, by that following the standard Leontief demand-pull calculus. Details on stressor intensity aggregations, EXIOBASE characterisation factor selections, and the derivation of environmental multipliers are outlined in SI7 – 9.

2.5 Methodological limitations

Despite all efforts, our model still bears certain limitations. First and foremost, no footprints for years later than 2010 could be assessed due to the lack of CES and MRIO data for these years. Also, weighted country-specific bridge matrices were only available for 2010. These were applied in the CES data reconciliations for both reference years, as changes were assumed to be negligible. Furthermore, the impacts were allocated economically, meaning the final demand was given only in monetary terms, which may have resulted in skewed environmental accounts of some products as compared to the usage of physical or mixed units (Tukker et al., 2016). Also, effects of the household share of fixed capital formation were not accounted for, despite their significance (Södersten et al., 2018). In addition, no uncertainty and sensitivity analyses, nor a multiple regression analysis across all socio-economic variables were conducted, as these would have been beyond capacity for the present study, because of their scope and complexity due to data stemming from different sources.

In conjunction with the above stated CES and MRIO data availability, a temporal mismatch between the complemented MRIO model and the characterisation factors of both impact assessment methods exists. That is, the former is available only for the years prior to 2010, whereas the characterisation factors were mainly valid for 2016 and later. However, it was assumed that over the years the characterisation factors would not have changed structurally, but only in their magnitude. More important than that, LC-Impact and ReCiPe differ considerably in their methodologies and assumptions; hence, a direct comparison between the two respective impact footprints must be treated with caution. Although both impact assessment methods account for biodiversity loss in their respective units, neither of them allows an interpretation of ecosystem functioning. That is, implications of impact footprints depend not only on the presently assessed species richness, but also on ecosystem resilience. However, LC-Impact's vulnerability scores for land and water stress already point in this direction. Moreover, taxa coverage differs between the methodologies and even across impact categories. Further, the high spatial detail of the original LC-Impact characterisation factors gets lost by averaging them per country when preparing for the MRIO calculus, whereas the globally-averaged ReCiPe characterisation factors provide too little spatial detail. And lastly, an allocation of environmental impacts to illegal activities such as illegal logging or poaching was not possible due to data unavailability – although the impacts were potentially accounted for through the impact assessment characterisation factors; thus, ecosystem damage due to illegal activities was falsely allocated to legal economic trade flows. For details on limitations of the applied LCIA methods, the reader is referred to the respective publications. Additional limitations are outlined in the corresponding subsections of the supporting information and in the discussion.

3 Results

3.1 European trends

According to either impact methodology, the European biodiversity footprint associated with household final demand in 2010 was in total 1.42E-3 PDF.yr or 5.97E+04 species.yr, and 2.83E-12 PDF.yr or 1.18E-04 species.yr on the per capita level, respectively.[8] While a decline of the European average by about 10% can be observed between 2005 and 2010, some countries show increased footprints in one or multiple impact categories, both on national average and per capita (see Figure S5 as well as Tables S14 – S20). Particularly countries with low to medium footprints such as Croatia, Lithuania, or Poland express this behaviour, but also Italy as a high-impact country does. Normalising these national footprints against the respective gross domestic product (GDP) reveals that between 2005 and 2010 only biodiversity impacts associated with Italian household consumption increased and that Bulgaria and Romania experienced the largest decreases (Figure S6).

In absolute terms, the countries responsible for the highest biodiversity losses are by far Europe's large economies, i.e. Germany, Italy, Spain, France, and the United Kingdom. On a per capita basis, however, results are less unequivocal – which is also linked to the choice of impact methodology (Figures S7 and S8). More specifically, ReCiPe footprints on the per capita level follow largely the GDP per capita, with Luxembourg and the Scandinavian countries showing the highest impacts. In comparison, LC-Impact footprints exhibit a twofold pattern: Mediterranean countries like Greece and Spain, and those with high per-capita GDP such as Luxembourg have the highest per capita biodiversity impacts (Figure 1).

The major driver of biodiversity losses is found to be land use. While the relative contribution of it varies across countries and impact methodologies, it is fairly stable over the years with not more than 5% deviation. The following numbers refer to the 2010 level. According to LC-Impact footprints, impacts caused via land use are most pronounced in the accounts of Mediterranean countries, except for Cyprus and Greece, with up to 92% in Portugal and 91% in Spain of the respective national total footprints. In contrast to that, land use is least distinct in Cyprus with only around 63%. The European average lies at 81%. In ReCiPe accounts, the share of land use is lower, however, with about 72% on the European level. It is highest in

[8] These values only account for the impact categories that are covered by both LC-Impact and ReCiPe footprints, i.e. land occupation, water stress, greenhouse gas emissions, and terrestrial acidification. For values on all impact categories per footprint type, please see the corresponding Excel files.

Croatia, Norway, and Lithuania (83 – 84%), and lowest in Greece, Cyprus, and the Czech Republic (60 – 61%). The second and third highest impact categories according to ReCiPe footprints are global warming with 16% and terrestrial acidification with 10%. In contrast, terrestrial acidification has the second highest share in LC-Impact footprints with 9%, closely followed by global warming with 8% (more than half of that is due to non-methane volatile organic compounds). The distribution of stressors across countries follows thereby the pattern of impact footprints. See Tables S21 and S22 for details.

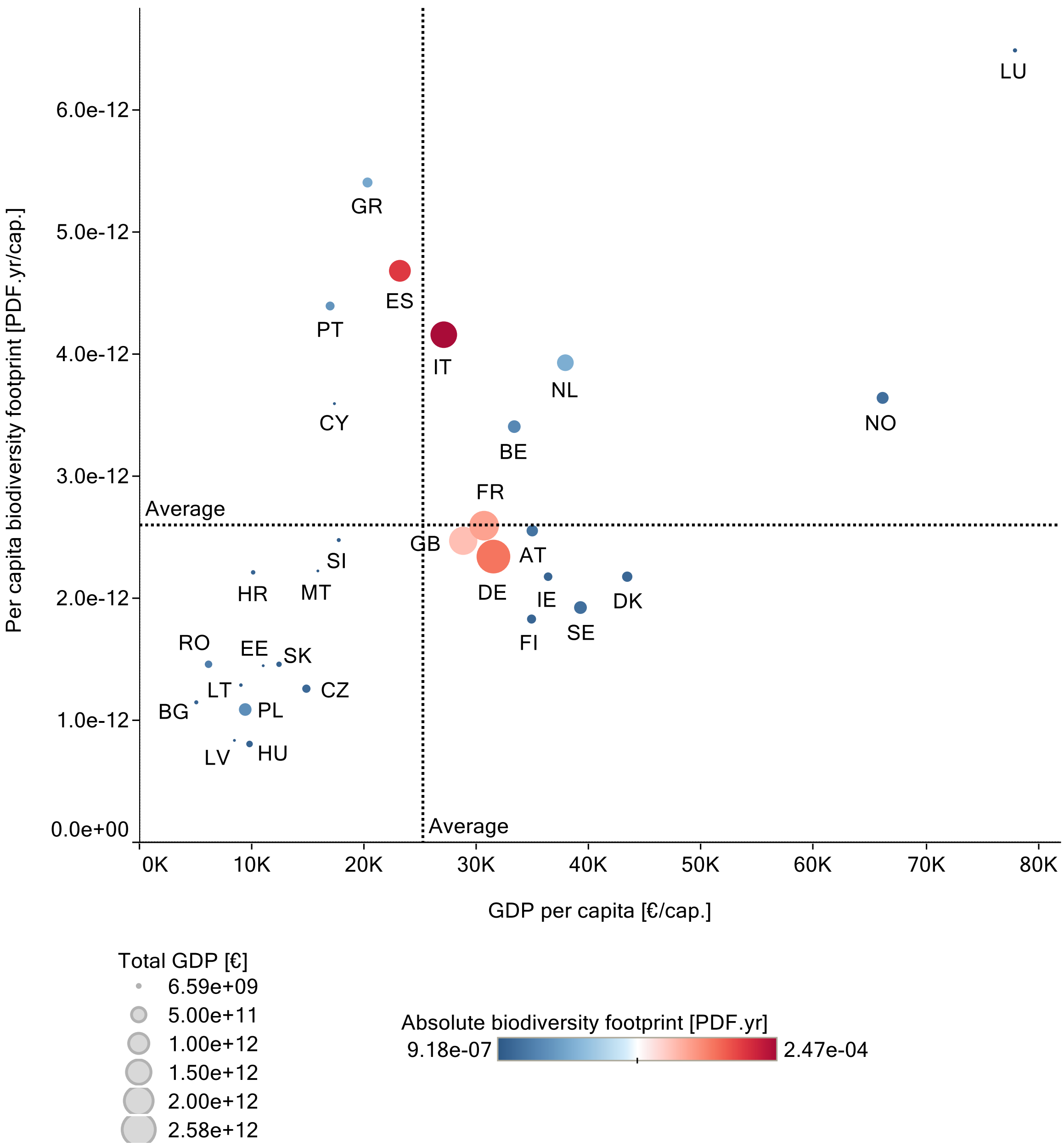

Figure 1: LC-Impact biodiversity footprint and GDP for 2010. Axes show per capita values; circle sizes indicate the magnitude of the total GDP; colouring denotes the magnitude of the absolute biodiversity footprint. See Table S2 for country abbreviations. The dotted lines represent the per capita footprint and GDP averages (see Tables S15 – S17).

3.2 Trade related biodiversity losses

European countries have a significant share of environmental pressures and impacts embodied in trade. All European countries are net importers of biodiversity losses (Table S23). Only about 31% of species losses attributable to total European household consumption are sourced from inside Europe. Around 40% of the exports of European countries stay within European boundaries. Except for Bulgaria, Spain, Greece, and Croatia, all of which have a higher domestic impact, most European countries have more imported biodiversity losses than domestically sourced ones (Table S24). The import shares are majorly highest for countries with high GDP per capita, namely Norway (95%), Belgium (97%), the Netherlands (each 98%), and Luxembourg (99%). For the remaining countries, import shares range typically from 50 to 70%. While most countries had even higher import shares in 2005, a few countries, most prominently eastern European ones, showed decreases in their domestic share from 2005 to 2010. The most noteworthy change during this period is, however, Italy's drop in import shares from 74 to 57%. A country's characteristic of being a net-importer or -exporter of species losses is, with slight fluctuations, also reflected in the individual impact categories.

European countries clearly differ as to where the sources of their imported biodiversity losses lie, e.g. RoW Africa being the largest contributor to France's footprint with about 23%, whereas only 5% of species losses attributable to Bulgaria's household consumption are sourced from RoW Africa. Overall, the largest sources for biodiversity footprints embodied in international trade for European consumption are RoW Africa (12.1%), RoW America (14.2%), and Spain (12.7%), followed by Italy (8.8%), RoW Asia and Pacific (6.7%), and France (5.4%). The largest absolute domestic flows of species losses are in Spain and Italy (Figures S9 and S10).

3.3 The effect of urbanisation

Both LC-Impact and ReCiPe biodiversity footprints in cities are, in absolute terms, higher than in towns or rural areas. On the European level, more than 50% of total ecosystem damage are caused by household consumption of urban populations. Towns are accountable for about 27%, and the remainder is due to final demand in rural areas. This same pattern can, however, be observed only across few individual countries, mainly the ones with high absolute footprints, i.e. Italy, the United Kingdom, and Germany. While urban areas have the highest share in total biodiversity losses in most countries, e.g. Cyprus (60%), Finland (65%), or the United Kingdom (61%), rural areas are often the ones with the second highest contribution, e.g. in Austria (37%), France (37%), or Ireland (34%). But there are also countries where the highest biodiversity footprints are borne by people living in the countryside, for instance, in Hungary, Sweden, and Slovakia with between 40 and 60%. The strongest signal of urban biodiversity footprints is in Malta with 93%. In Latvia, cities and rural areas are responsible for about 50% of the national biodiversity footprint each.

Both on the per capita as well as per household levels, differences are, however less distinct. A city resident is accountable for about 5% higher biodiversity losses than the average European citizen, whereas suburban residents have biodiversity footprints that are only 2% higher, and

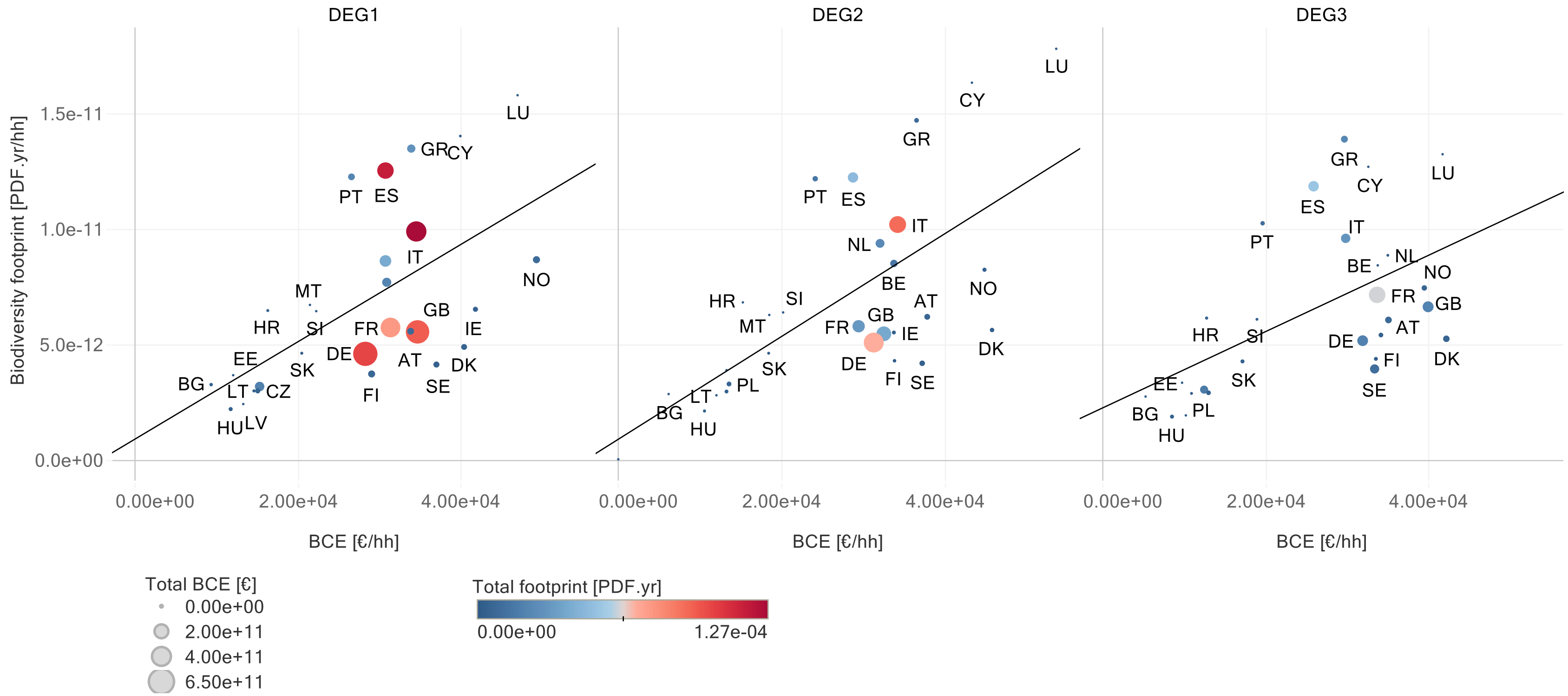

Figure 2: LC-Impact biodiversity footprints disaggregated by degrees of urbanisation for 2010. The axes show the biodiversity footprints and balanced consumer expenditure (BCE) per household; circle sizes indicate the total balanced consumer expenditure (small – low, big – high); colouring denotes the total biodiversity footprint (blue – low, red – high). The dotted lines are linear trend lines. DEG1 = cities, DEG2 = towns, DEG3 = rural. See also Figure S11 and Tables S25 – S26.

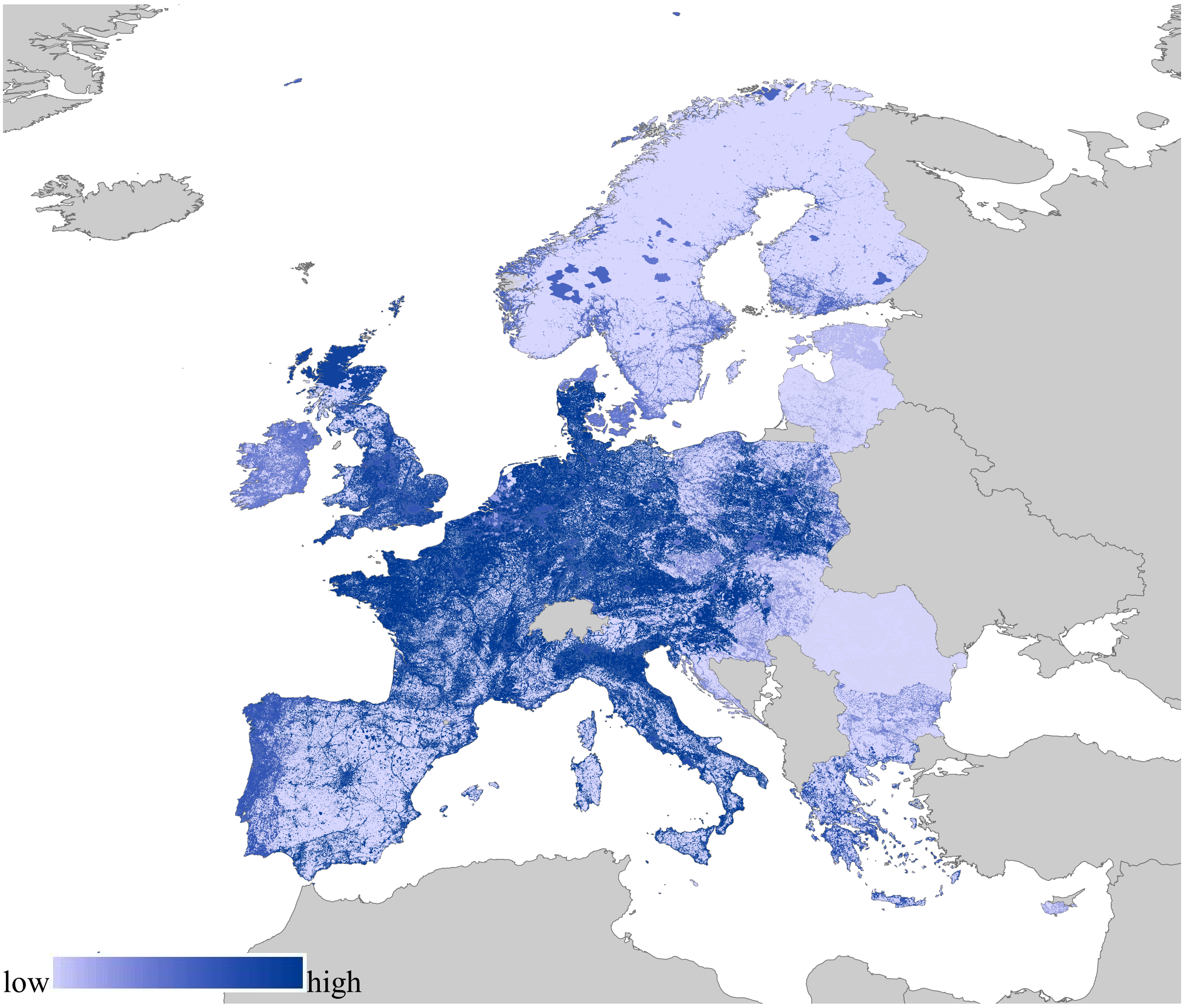

Figure 3: Absolute LC-Impact biodiversity footprints of Europe in 2010. Blue shaded areas indicate the magnitude of biodiversity footprints across all degrees of urbanisation; grey areas were excluded from analysis. The footprint values per country are based on country averages per degree of urbanisation. See SI11 for more details.

rural residents have footprints that are 12% lower than average.[9] While this is also the case in most countries, some exceptions do exist: in small economies such as Bulgaria, Croatia, Hungary, or Ireland, the per capita biodiversity footprint distribution shares of city populations are relatively higher than the European city distribution share. Conversely, rural populations in, amongst others, France and the United Kingdom have a stronger per capita impact on biodiversity compared to the average European city resident. While the biodiversity footprints of Norwegians living in cities and towns as well as those of Finnish rural residents are highest in direct comparison across Europe according to the ReCiPe assessment, it is Luxembourg citizens in cities and towns as well as Greek rural residents when applying the LC-Impact methodology. For a comparison on the per household level, see Figure 2 as well as Figure S11. In either case, biodiversity losses disaggregated by degree of urbanisation correspond to the balanced consumer expenditure, i.e. the higher the expenditure, the higher the footprint.

[9] For ReCiPe biodiversity footprints, the differences are +3% (city), -3% (town), and -3% (rural). This pattern can be found across most European countries when using the ReCiPe method.

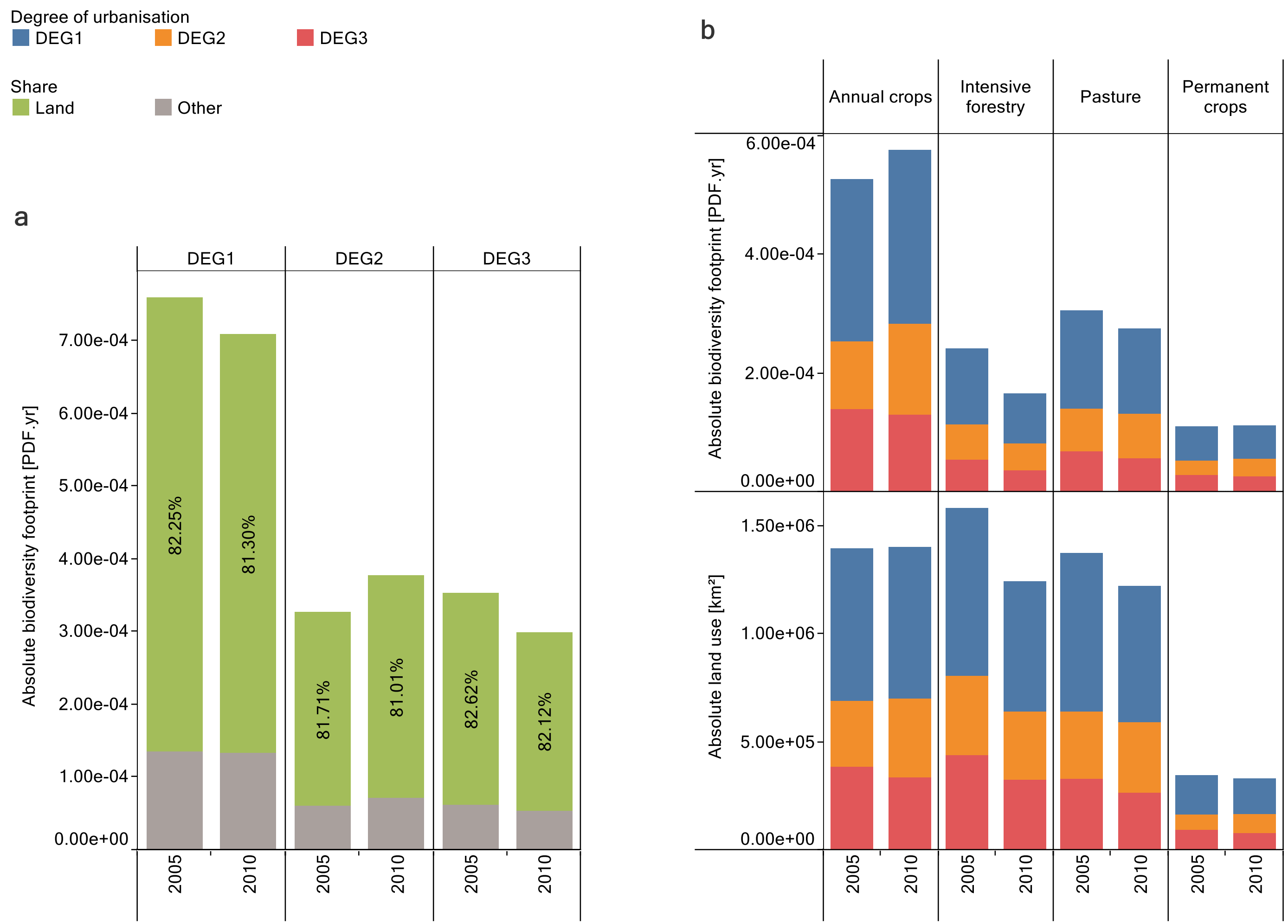

Figure 4: Differences across urbanisation degrees and the importance of land use. a) shows the absolute biodiversity footprint per degree of urbanisation, indicating the share of land use; b) shows land use pressure and impact disaggregated by land use type and the share of each degree of urbanisation. DEG1 = cities, DEG2 = towns, DEG3 = rural. For Ireland, Malta, the Netherlands, and Sweden, no disaggregated 2005 data was available; therefore, 2010 data was used for these countries. Romania is not included due to a lack of data in both years.

The relative breakdown of impact categories *per* degree of urbanisation in a country differs only slightly, i.e. max. 3%, compared to national averages, both in absolute and per capita terms for all countries. That is, for instance, Germany's share of land use on all urbanisation levels of around 78% in 2010 is about the same as in its national average. However, comparing the contributions per impact category *across* the urbanisation levels shows that in most countries and impact categories city residents are more accountable than people living in towns or in the countryside. Scaling this to the European level, urban citizens carry higher weights in the categories of land occupation, water stress, and others (up to 7% higher than the average per capita footprint per impact category), whereas people living in towns have higher footprints than the average European citizen regarding ecosystem damage related to emissions of, for example, fossil methane and sulphur hexafluoride (Tables S27 – S29).

Land use prevails as highest contributor to the overall biodiversity footprint across cities, towns, and rural areas. While the absolute land use for annual crops, intensive forestry, and pastures is of similar magnitude, it is annual crops that have the greatest impact (Figure 4 as well as Figure S12). The ratios of urbanisation degrees within each land use type are comparable to the total.

3.4 Product-level drivers

As shown in Figure 4, land use accounts for the major share of biodiversity losses attributable to European household consumption. Hence, product sectors based on land use have the highest impacts embodied. These sectors are particularly food related ones, but also services and the manufacturing of household commodities carry some weight (Figure 5). Disaggregating the sectoral contributions by household type indicates that two-person households, with and without children, have the highest absolute footprints, accounting together for about 60% of total ecosystem damage associated with European final demand (see also Table S30).

However, biodiversity losses per household display a different pattern (Figures S13 – S15). While the relevance of animal-based food sectors drops, services as well as plant-based and other food sectors increase in their contribution. Moreover, household footprints of the distinct household types largely depend on the sector. For instance, single person households and those with three or more people have the highest share in the service sector, whereas for manufactured goods most of the footprint is attributable to the consumption of households with two persons. On European household average across all sectors, it is single person households, followed closely by two-person households, with the highest footprint across all impact categories.

As mentioned earlier, land use related species losses are mainly caused by the demand for food, both animal- and plant-based, and food related products. Particularly Europe's consumption of vegetables, fruits, nuts, and meat entails strong negative impacts, but also hotel and restaurant services. The former products, together with other crops, are also the main driver for biodiversity losses through water stress. Moreover, textile products as well as services impact ecosystems largely via land use, although their contribution is considerably lower than that of food products. Most impacts on biodiversity due to terrestrial acidification and greenhouse gas emissions are attributable to products associated with the food and mobility product sectors. The demand for chemicals and gasoline is the main driver of additional species losses through photochemical ozone formation. Freshwater eutrophication induced impacts, on the other hand, are mainly caused by leather, as well as meat and other food products. See the corresponding spreadsheet appendix for more details.

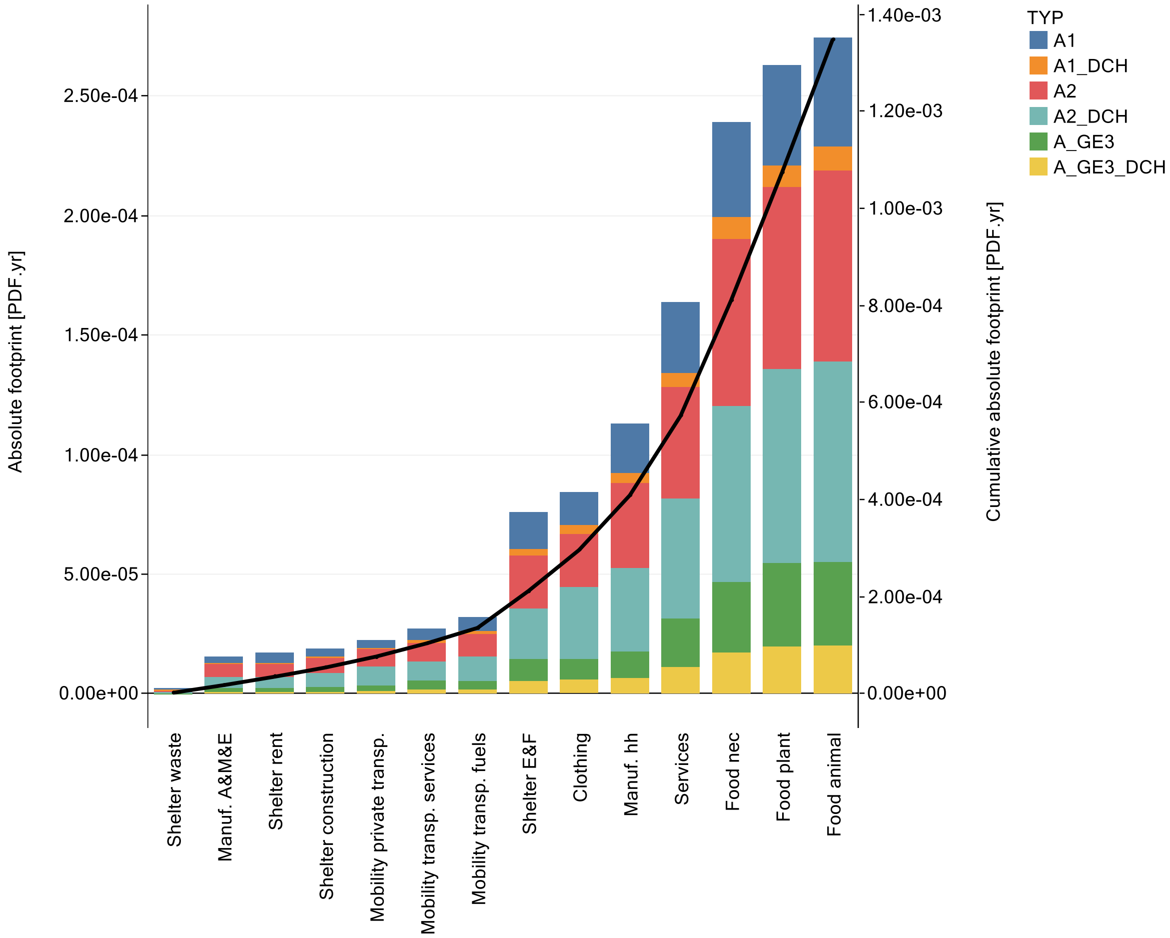

Figure 5: LC-Impact biodiversity footprint per sector for 2010. The primary axis describes the absolute European footprint disaggregated by types of households (stacked bars), whereas the secondary axis scales the cumulative absolute European footprint (black line). The sector grouping was established using a concordance matrix (EXIOBASE sector to sector group) from Ivanova et al. (2017). Colouring denotes the distinct types of households.[10] The full sector group names can be found in Table S31.

3.5 Income as a determinant for impact

While we find that both per capita and absolute biodiversity footprints increased with increasing income in 2010, no such development can be observed for 2005 (Figure 6 as well as Figure S16). More specifically, the absolute footprint still follows the former pattern, although less

[10] The household type classification is as follows: A stands for adult, with the following cipher denoting the number of adults; GE stands for greater than or equal; DCH stands for dependent child/children. For example, A1_DCH describes a single household with one or more dependent child/children.

pronounced than in 2010, but per capita biodiversity impacts associated with final demand in low income quintiles are considerably higher in 2005. The per capita footprints attributable to Europe's second income quintile even exceeds the footprint attributable to the fifth income quintile.

However, when normalising the biodiversity footprints against the respective balanced consumer expenditure, the patterns for both years resemble one another (Figure S17). Across both reference years and all European countries, these normalised footprints decrease, the lower the income. Independent of the normalisation procedure, land use accounts in both years and across all income quintiles for most of the biodiversity footprint, ranging from around 80% (71% for ReCiPe) for quintile five in 2010 to slightly above 84% (73% for ReCiPe) for the first quintile in 2005.

4 Discussion and conclusion

In this study, we examined the role of various socio-economic variables regarding environmental impacts associated with European household consumption. We applied an MRIO approach, extended by selected LCIA methodologies to account for biodiversity losses. The required trade data from EXIOBASE v3.4 was ameliorated with CES data from Eurostat to allow for the disaggregation of household final demand.

While large economies such as Germany and the United Kingdom generally have high absolute footprints, per capita footprints depend on multiple factors. The influence of each country's economic performance was demonstrated via normalisation of biodiversity footprints against the respective national GDP. A decrease in both absolute and per capita footprints in the period 2005 – 2010 was identified for the European total and most individual countries. Because GDPs of most European countries increased at the same time, a decoupling of biodiversity impacts from affluence is indicated. With only two reference years, a discussion on the influence of the Euro crisis is not possible, though. Differences within each country exist across impact categories as well as within each impact category across countries. Particularly the relevance of eutrophication and acidification increased in most countries in the respective period, although being generally low in comparison to land use. For these reasons, nations must tailor country and market specific solutions for reducing their environmental impact.

Moreover, the ranking of national biodiversity footprints depends largely on the chosen impact assessment methodology. That is, although ReCiPe and LC-Impact footprints show a similar overall pattern, they differ in detail across European countries. While per capita footprints according to the ReCiPe methodology generally increase with higher GDP per capita, the same footprints according to LC-Impact depend on both GDP per capita and the location of the country. These deviations can be attributed to the different nature of the respective footprint types and the underlying methodology. A brief discussion on fundamental implications regarding the choice of impact methodology is provided in SI12.

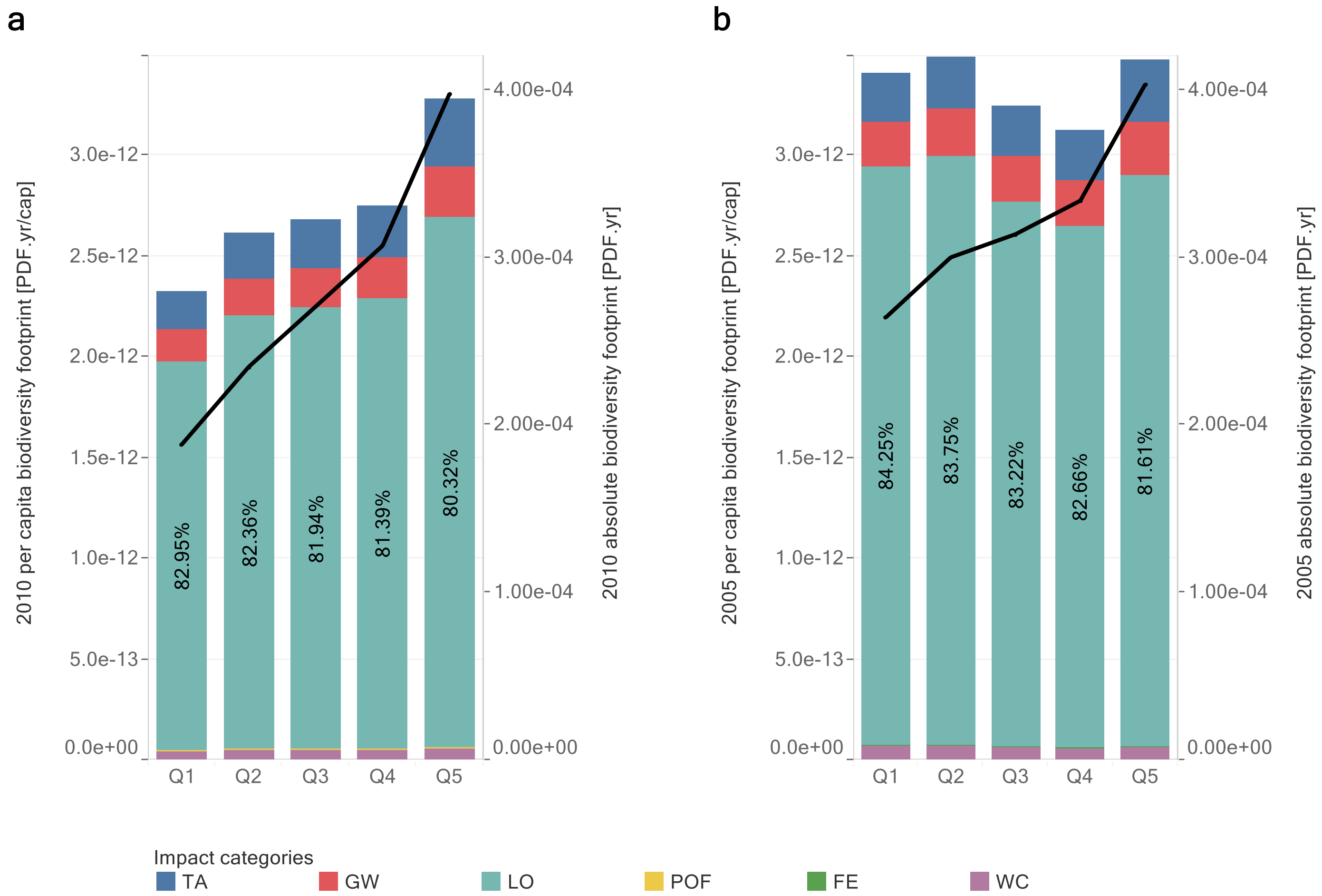

Figure 6: LC-Impact biodiversity footprints disaggregated by income quintiles. a) shows 2010 footprints, b) shows 2005 footprints. The primary axes describe per capita footprints, whereas the secondary axes scale absolute footprints. Colouring denotes different impact categories: FE – Freshwater eutrophication, GW – Global warming, LO – Land occupation, POF – Photochemical ozone formation, TA – Terrestrial acidification, WC – Water consumption. Mind that the 2005 footprints do not include the contribution of Ireland and Sweden due to missing data; replacing these with 2010 data as in Figure 3 is not possible due to the nature of data. No data on income quintiles in Norway were available in either year.

Just like the selection of impact assessment methodology gives differing results, the choice of MRIO database may also influence them. An investigation of this was not attempted here, but other examples exist that demonstrate this (Geschke et al., 2014; Moran & Wood, 2014; Wieland et al., 2018). However, as reasoned earlier in sections 2.1 and 2.2, choosing EXIOBASE appears most appropriate when assessing European household consumption. As already described in section 2.5, the differing year coverage of CES/MRIO data and LCIA characterisation factors is more concerning. There is a strong need for more up-to-date economic data; the time lag between data collection and publication hampers the timely assessment of societal changes and the adequateness, usefulness, and efficiency of environmental policies. And although the latest data on expenditure structure provided by Eurostat (2018b) is from 2010, not even all countries were covered in each socio-economic variable, e.g. Italy and Luxembourg were not covered for income. Nevertheless, the effect of most of the surveyed socio-economic variables could be assessed for most European countries in both reference years.

While urbanisation has a major influence on the absolute biodiversity footprints of countries, it is less pronounced on the per capita and per household levels. The high share of species losses attributable to city residents on a national level is mainly due to the size of urban populations in Europe. In times of urban sprawl, related social and demographic changes, as well as society's high impact on the planet, sustainable urban development and regional planning become more important than ever before. Moreover, it can be observed that absolute biodiversity footprints in each degree of urbanisation follow the magnitude of the total GDP and the population size across all countries and all impact categories. The variation of national per capita footprints across all levels of urbanity and all impact categories, however, has a less clear signal. Nonetheless, we find that both absolute and per household footprints are correlated to GDP and balanced consumer expenditure across all degrees of urbanisation.

In relation to that, it was shown that income is a major driver of biodiversity losses due to household final demand on absolute national averages and for whole Europe. That is, the higher the income, the higher the footprint. This is in alignment with studies explaining the magnitude of environmental pressures with both expenditure and income (Jones & Kammen, 2014; Chancel & Piketty, 2015; Ivanova et al., 2016; Steen-Olsen et al., 2016; Ivanova et al., 2017). While that holds also for the 2010 per capita level, per capita footprints in 2005 appear to be decoupled from income. Such variation can, however, be explained by expenditure patterns. That is, per capita footprints in proportion to per capita expenditure decrease from low to high income for both reference years. While the raw results of the income-footprint nexus extend the finding of non-saturation regarding environmental pressures with increasing wealth by Hertwich and Peters (2009) and others, the normalised results rather corroborate the controversial hypothesis of the environmental Kuznets curve (Stern, 2004). A definitive, generalised answer on the role of income across both, absolute and per capita, levels is therefore not possible, but differentiation is necessary. Similarly, the role of household size differs depending on which perspective is taken: absolute or per capita.

In line with other biodiversity footprint studies (Verones, Moran, et al., 2017; Wilting et al., 2017), land use was found to be the major contributor to biodiversity losses. Land use, in turn, was shown to be mainly driven by the demand for agricultural food products, which is in accordance with Wilting et al. (2017) and Kitzes et al. (2017). The impacts of this demand and other European consumption are, however, to a large extent imposed on countries in other regions of the world, whereas domestically caused species losses are considerably lower. The import share of Europe as a whole and most of its individual countries is greater than their exports, i.e. Europe being a net-importer of biodiversity losses. This aligns with earlier studies on environmental pressures (Giljum et al., 2016; Lutter et al., 2016; Wood et al., 2018) and impacts (Lenzen, Moran, et al., 2012; Kitzes et al., 2017; Wilting et al., 2017), outlining Europe's leverage. Such an imbalance may be source for ethical demur and raises the question of producer vs consumer responsibility (Lenzen et al., 2007) – an answer to which shall not be attempted here.

Additionally, the impact distribution is sector dependent. Therefore, directed intervention via policy instruments such as taxes on certain goods for curbing further ecosystem damage associated with household consumption is not straight-forward. With the highest biodiversity losses embodied in agricultural products, the discourse on the role of food and non-food commodities must be widened to reach multiple stakeholders including the public, the scientific community, and policy-makers. Differences regarding the environmental performance of producers of agricultural products as well as the effectiveness of environmental policies and regulations could not be analysed here but should be addressed in future research.

The focus of the present study is on Europe. Although we demonstrated substantial differences in biodiversity footprints across European countries, even more pronounced differences can be expected when extending the scope to a global assessment; i.e., to examine ecosystem damages attributable to household consumption also in other parts of the world. Whilst assumptions on the general results may be quick at hand, evidence is lacking. For such a global assessment, detailed data must be available, including: i) weighted and country specific bridge matrices for different sector classifications; ii) datasets differentiating the expenditure pattern into the various socio-economic variables and respective parameters; iii) comprehensive MRIO data; iv) spatially differentiated endpoint characterisation factors across multiple impact categories.

As pointed out earlier, all this data would need to be up-to-date to allow for directed action in a timely manner. The spatial component of such action is influenced by the level of detail of such footprints. That is, while footprints presented here are on a virtual sub-national level, no identification of biodiversity loss *hotspots* attributable to a country's final demand is possible. This is despite the availability of spatially explicit characterisation factors; but aggregating them to the country scale leads to a loss of detail, which can be described by the modifiable areal unit problem (Wong, 2004). Hence, species occurrences and biodiversity losses are regarded as evenly distributed within one country. Similar difficulties were already faced by Moran and Kanemoto (2017). An advancement into the direction of disaggregated, spatially explicit consumption-based accounts is therefore crucial. A possibility could be the combination of the present model with the approach by Godar et al. (2015) – provided sufficient availability of regionalised production data.

An identification of entire supply chains and production layers could further our understanding of why and where environmental impacts occur. Uncertainty and sensitivity analyses would add additional detail but would require more information on the source data. In future research on the present topic, the multi-impact assessment character as presented here must be preserved to avoid potential problem shifting. Additionally, as a next step of the parallel analysis of socio-economic variables undertaken in this study, a simultaneous disaggregation of income and urbanity would deepen the understanding of a combination of drivers and enable adequate policy responses.

Concluding, our analysis demonstrates the influence of multiple socio-economic variables on the magnitude of biodiversity losses associated with household final demand. Given that urbanisation is expected to increase and that more countries strive for ever more wealth, stronger impacts on the environment would be the consequence, both domestically and, even more so, abroad. Therefore, political action is crucial – yet, not only that: the responsibility of the individual is also asked for to avert further negative environmental corollaries of household consumption. Be it environmental laws and regulations, or just the decision of the individual to abstain from, for instance, meat consumption and do without the extra cup of coffee in the morning, both behavioural and structural changes could reduce humanity's footprint on the planet.

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Supporting information

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List of abbreviations

Matrices and vectors

Symbol	Dimension	Explanation
β	$1 \times p$	Number of households per country and variable
δ	$1 \times p$	Distribution of households per country and variable
ε	$1 \times p$	Underreporting per country and variable
ϑ	$1 \times p$	Structure of reported expenditures per country and variable
φ	$1 \times p$	Number of persons per household per country and variable
A	$n \times n$, $mn \times mn$	Direct requirements matrix (single region and multi-region)
B	$u \times y$, $mn \times y$	Biodiversity impact footprints (different configurations)
C	$f \times s$	Characterisation matrix
d	$1 \times mk$	Environmental pressure vector
D	$s \times mk$, $d \times y$	Environmental pressure matrix, pressure footprint (specific configuration)
E		CES expenditure matrix per country (multiple configurations throughout its reconciliation)
F	$s \times mn$	Total emissions matrix
h	$1 \times p$	Total number of households per country
I	$n \times n$, $mn \times mn$	Identity matrix (single region and multi-region)
j	$1 \times m$	Weighted characterisation factors per impact category
L	$n \times n$, $mn \times mn$	Leontief inverse matrix (single region and multi-region)
m	$u \times mn$, $r \times mn$	LC-Impact/ReCiPe environmental multiplier
n	$f \times mn$	Midpoint environmental multiplier
p	$1 \times p$	Population per country and variable
P	$f \times y$	Characterised pressure footprint
Q	$u \times mn$	LC-Impact characterisation factors, sector expansion
R	$r \times 1$	ReCiPe mid- to endpoint conversion factors
S	$s \times mn$, $d \times mn$	Stressor intensities matrix (different configurations)
T	$mn \times mn$	Trade matrix
W	$n \times (l+1)$	COICOP-EXIOBASE bridge matrix
x	$n \times 1$	Total output vector
X	$mn \times m$	Total output matrix
y	$mn \times 1$	Final demand vector
Y	$mn \times m$, $mn \times mk$, $mn \times y$	Final demand matrix (different configurations)
Z	$n \times n$	Inter-industry requirements matrix (single region)

Indices – subscripts

c	number of CES countries
g	grid cell
i	number of socio-economic variables
m	number of MRIO countries
n	number of sectors in MRIO model
k	number of final demand categories
l	number of sectors according to COICOP classification
p	number of parameters per socio-economic variable
r	number of ReCiPe impact categories
s	number of stressors
t	year (subscript not used in respective equations, because all equations go for each reference year in individual cycles)
u	number of LC-Impact impact categories
v	generic number of impact categories (either u or r)

Indices – superscripts

balanced	denotes disaggregation of mean expenditure
bp	basic price
COICOP	indicates accordance with the COICOP sector classification
COICOP +	indicates accordance with the COICOP sector classification and consideration of CES underreporting
EXIO	indicates accordance with the EXIOBASE sector classification
hh	per household level
LC-Impact	indicates accordance with LC-Impact impact assessment methodology
mean	denotes mean expenditure
national	national level
pp	purchaser price
ReCiPe	indicates accordance with ReCiPe impact assessment methodology
raw	denotes the basic configuration of the LC-Impact characterisation matrix, i.e. without the sectoral repetition per country
selected	denotes a selected set of, for instance, stressors
structure	indicates disaggregation by socio-economic variable
trade	denotes inclusion of trade in final demand
underreported	denotes underreporting of CES expenditure

Acronyms

AGE	Age of main income earner
AIIOT	Asian international input-output table
BRICS	Brazil, Russia, India, China, South Africa
CES	Consumer expenditure survey
CF	Characterisation factor
COICOP	Classification of individual consumption according to purpose
DEG	Degree of urbanisation
DPSIR	Driver, pressure, state, impact, response
EE-IO	Environmentally extended input output analysis
EE-MRIO	Environmentally extended multi-regional input output analysis
EOO	Extent of occurrence
EU	European Union
EXIO	EXIOBASE sector classification (163 industries, 200 products)
FAO	Food and agriculture organisation
GDP	Gross domestic product
GHG	Greenhouse gas emissions
GRAM	Global resource accounting model
GTAP	Global trade analysis project
HANPP	Human appropriation of net primary productivity
HFCE	Household final consumption expenditures
ICE	Individual consumption expenditure
ICIO	Inter-country input-output database
INC	Income
IO	Input-output analysis
IOT	Input-output table
IUCN	International Union for Conservation of Nature
LCIA	Life cycle impact assessment
MRIO	Multi-regional input-output analysis
OECD	Organization for Economic Cooperation and Development
PDF	Potentially disappeared fraction of species
POCP	Photochemical ozone creation potential (also: photochemical ozone formation)
pSUT	Physical supply and use table
RoW	Rest of the world
SEI-PCS	Spatially Explicit Information on Production and Consumption Systems
SUT	Supply and use table
TYP	Type of households
UK	United Kingdom
US(A)	United States (of America)
WIO	Waste input-output model
WIOD	World input-output database

SI1. Consumption-based vs production-based accounts

Emissions and resource uses of a country or region can be allocated differently. Two major perspectives, both based on the Leontief approach (SI2 and 6), exist for doing so: Following the explanation by Wiebe and Yamano (2016), consumption-based accounts allocate all emissions and resource uses associated with the final domestic demand to the country or region where this demand occurs, whereas production-based methods allocate emissions and resource uses directly to the country or region where they occur. While both approaches in their environmental extension traditionally only account for emissions and resource uses, i.e. environmental pressures, their definition is expanded in this study to also account for environmental impacts such as biodiversity loss.

Similar to Wiebe and Yamano (2016), an example may better illustrate the difference between production- and consumption-based accounting. Take soap in plastic packaging that you buy in Norway - the soap itself was produced in the Netherlands using domestic water resources, but its other ingredients were sourced from Indonesia (palm oil), France (scents), India (lye), and China (essential oils and colour). The plastic packaging, however, is petroleum-based and was produced in the UK, while the paper for the labels was produced in Germany using Swedish timber. The production-based technique would now allocate all environmental pressures (and their associated impacts) to the countries where the emissions and resource uses occur when producing or refining the ingredients/products. The consumption-based approach, however, would allocate all environmental pressures/impacts to the country of final demand, i.e. where you buy the soap.

For both approaches, (multi-regional) input-output analysis (MRIO/IO) is the method of choice when it comes to national or international assessments, as will be outlined in the succeeding literature review. When the aim is not only economic assessments, but environmental ones, one speaks of environmentally-extended (multi-regional) input-output analysis (EE-MRIO/EE-IO). For an introduction to the basics of EE-(MR)IO, the underlying standard Leontief demand-pull model, and an elaboration on the applied analytical MRIO model, the reader is referred to sections SI6 and SI7.

SI2. Input-output analysis and footprint methods – a brief review

The present study is not the first one that uses MRIO for environmental assessments. Conversely, a plethora of publications exists that have applied this top-down approach for estimating environmental footprints across multiple countries on different scales and with different foci. While some are of purely theoretical nature, others even go as far as to raise the question of producer vs consumer responsibility based on concrete examples.

The following overview is designed as an introduction to the existing literature on the topics of environmental footprints in general and spatially-explicit biodiversity assessments in particular, as well as their development over the last years. This overview mainly focuses on the methodologies applied in these publications and their limitations. For readability, citations of these studies are only given in the beginning of the paragraphs on the respective publications.

Citations for MRIO databases, that were used in these studies, are left out in the following, yet are included in the separate section on MRIO databases (SI3); if studies described below used earlier versions of these MRIO databases, the reader is referred to the respective sources. Similarly, the reader is referred to the respective sources for details on other databases containing information on emissions, species ranges, or similar.

Environmental accounts in various domains

Given the advancement of European policy strategies towards resource efficiency as well as a lack of material footprint assessments for Europe, Giljum et al. (2016) examined European final demand for primary materials in the period 1995 – 2011. The authors combined EXIOBASE version 3.1 data with the WU Global Material Flow database (WU, 2015), and deployed besides the standard MRIO footprint approach also a production layer decomposition. While it was shown that the overall material footprint of the EU increased by about 50% in the respective period, the EU's share of domestically extracted raw materials decreased by about 30% to only 35% in the same time span. Similar to Tukker et al. (2016), the authors found construction materials to be dominating the total material footprint with around 50% in 2011. In addition, about half of the EU's total mineral footprint is made up by Chinese exports. The authors pointed at uncertainties connected with the source databases as main limitations of their study.

China was also found to be the main export country of raw materials in an earlier study on material footprints of 186 economies in 2008 by Wiedmann et al. (2015), while the countries with the largest imports were the US and Japan. This lead to China having by far the highest material footprints, followed by the US with an about 50% lower footprint. Wiedmann et al. (2015) also found a clear link between the wealth of a country and its material footprint; more specifically, the average national material footprint increased by 6% for every 10% increase in GDP. Concurrently, the domestic share of a country's material footprint reduced with increases in wealth.

A somewhat different MRIO-model was created by Tisserant et al. (2017) who calculated waste footprints for 48 world regions and 11 waste types in the year 2007. Trade data was derived from EXIOBASE and given in monetary units to which physical waste flows were appended in physical units. The method was largely based on the waste input-output (WIO) model by Nakamura and Kondo (2002). The application of mass balances for dry matter content of materials and waste yielded physical supply and use tables (pSUT). Liquid waste and unused domestic extraction were excluded. The authors noted that the calculated waste amounts were higher than those reported by official statistics; the deficit was regarded as unregistered waste and appended to the pSUT. The monetary SUT and the pSUT were combined to create a mixed-unit square SUT. Based on the latter, the A-matrix was then built using a product substitution construct, a generalised by-product technology construct. The stressor matrix, serving as an identity matrix in the WIO-model, was used to allocate waste to various treatment options. The authors found that 3.2 gigatonnes of waste were generated globally in 2007 and that waste generation patterns varied strongly across regions, with Russia being the largest contributor, followed by China and the US. Moreover, the higher the per capita income, the more recycling took place in the respective country and even more in foreign countries. Across all regions the share of municipal solid waste was less than 50%. Data availability was regarded as one of the main constraints in this publication.

In their recent study on eutrophication potentials, Hamilton et al. (2018) applied an MRIO model based on MRIO data from EXIOBASE version 3.4. Following the characterisation method ReCiPe (Huijbregts et al., 2017), marine and freshwater eutrophication were accounted for through Nitrogen and Phosphorous emissions, respectively. The actual Phosphorous and Nitrogen emissions were derived using a mass balance approach based on crop production levels retrieved from the FAOSTAT database and nutrient demand from FAO. The authors found that China, followed by India, had the highest marine eutrophication footprint in 2011; in comparison, 2011 freshwater eutrophication footprints were highest in the US and China, followed by Brazil. Furthermore, the authors evaluated time series data for the period 2000 – 2011: for both eutrophication types and across all years, food products were primarily accountable, with crop production being a major component in marine eutrophication footprints and animal husbandry in freshwater eutrophication footprints. In addition, the total global eutrophication footprints increased over the respective period. Applying cross-sectional and panel data regression analyses, the authors identified affluence, i.e. per-capita GDP, as a driver of both marine and freshwater eutrophication footprints.

Another environmental domain of interest is water consumption. Given the relevance of global water stress, Lutter et al. (2016) assessed water footprints for final consumption in the EU-27 in the year 2007. In comparison to the national scarcity-weighted water footprints in Lenzen, Moran, Bhaduri, et al. (2013), that were calculated for 187 countries and were based on Eora, this study by Lutter et al. (2016) goes down to the watershed level by combining EXIOBASE version 2.2 data with detailed information on water withdrawal and consumption from relevant source datasets such as the WaterGAP model (Floerke et al., 2013). The general method for environmental accounting followed the approach by Ewing et al. (2012; see further below), yet was modified to allow for further disaggregation of each sectors' footprint into shares per watershed. In addition, also scarcity of blue water in terms of duration and severity was accounted for via the blue water scarcity index by Hoekstra et al. (2012). Green water pressure hotspots were identified for Europe, central North America, the southeast of South America, Southeast Asia, and the Sahel zone, whereas hotspots for blue water consumption were found to be in the southwest of Europe and in the India-Pakistan region. This aligns with the findings in Mekonnen and Hoekstra (2011). Of all products, agricultural ones generally showed the highest water consumption, particularly within the EU and in Asia. Moreover, 76% of the green water and 65% of the blue water consumed in the EU-27 were sourced from outside. The highest pressure lay on the river Indus with wheat and oil seeds being the crops with the highest embodied water, followed by the Mississippi and the Danube. When it comes to scarcity, the Indus was by far the river severest affected by final consumption in the EU-27. The products with the highest embodied blue and green water consumption are, scarcity-weighted, animal products from agriculture, processed crop products, as well as sales and retail services. The authors identified the rough product detail and the limited spatial resolution outside Europe as the main limitations of this study, both of which highlight the role of data availability, particularly regarding MRIO databases.

With their SEI-PCS model (Spatially Explicit Information on Production and Consumption Systems), Godar et al. (2015) present a spatially explicit accounting technique. This approach applies a minimum cost allocation analysis based on linear programming. Although this model does not assess the actual environmental burden, it is a step into the direction of spatially differentiated consumption-based accounts. Following the optimisation procedure, the essential step in this method is the multiplication of three matrices: a domestic material flows matrix, a bilateral trade matrix, and a matrix showing the net flows in import countries. The downside of this technique is the need for a wealth of detailed data. In an example on Brazilian soy for the period 2001 – 2011, the authors showcase how such data from a multitude of sources gets combined in the model and what the results are, measured in physical units and in land area. Brazil, China, and the EU were the largest consumers of Brazilian soy across all production sites, although differences in regional weight exist. It became apparent how the more accurate link between production and consumption improves the understanding of trade dynamics. A similar study partly based on the same model was applied by Flach et al. (2016) on virtual water flows sourced from Brazil.

Inequality in carbon

Despite advancements into the above mentioned environmental domains and others, one of the most popular applications of MRIO is the assessment of carbon footprints. In their landmark study, Chancel and Piketty (2015) examined the global inequality of carbon emissions and the role of carbon embodied in international trade. The authors relied on an MRIO approach in combination with additional data. The Lakner-Milanovic dataset (Lakner & Milanovic, 2013) was rescaled to the Worldbank's household final consumption expenditures (HFCE). In addition, the former was expanded by updates on GDP, HFCE, and population data. Estimates for top 1% income shares were modelled through a regression. Income distributions for countries missing in the original dataset were reconstructed. Data on all these income distributions were then combined with GTAP MRIO data. The authors assumed a proportionality between carbon emissions and population per country. Through that, national averages were rescaled to income shares and per capita. Interestingly the per capita averages of each region are higher than what is assumed to be required for a sustainable consumption, i.e. 1.3 tCO_2e/cap/year. While the calculated world average of carbon emissions per capita was 6.2 tCO_2e in 2013, 50% of the world population had a per capita footprint of less than half of that amount. Moreover, the top 10% emitters were accountable for about 45% of global emissions, whereas the bottom 50%, e.g. Honduras, Mozambique, and Rwanda, were responsible for only about 13% of global emissions. Western countries clearly dominated the distribution of emissions, with the top 1% of USA and Luxembourg being at the very top, followed by the top 1% of Singapore, Saudi Arabia, and Canada. Over the years, i.e. from 1998 to 2013, the level of CO_2e emissions inequality between countries decreased, whereas it increased within countries. The authors obtained also further results and made respective conclusions, e.g. on carbon tax strategies; these are, however, of no relevance for the present overview. The largest limitation of this study is the need for improvement of income distribution estimates and carbon-income elasticities.

The divide between consumer and producer responsibility was also touched upon in a study by Kanemoto et al. (2016). More specifically, it was shown how final consumer demand drives direct and indirect greenhouse gas (GHG) emissions (here: CO_2, CH_4, and N_2O) domestically and abroad. These spatially explicit carbon footprints are based on emission accounting as described in Kanemoto et al. (2012), in turn based on the Leontief standard input-output calculus, and a combination of the Eora MRIO database and the EDGAR greenhouse gas emissions database, including industry-specific emission maps of the latter. Mapping the different sector classifications of Eora and EDGAR allowed the (spatial) calculation of emission hotspots. The study highlights the problem of carbon leakage and, for most developed countries, a spatial growth of carbon footprints for the period 1970 – 2008. Concurrently, a growth of urban emissions faces a relative decrease of emissions in rural areas. It can also be observed, that domestic carbon footprint hotspots of one country differ from the hotspots in that country driven by the consumption in another country. Also, the footprints per country and per sector differ for the various GHGs which allows the conclusion that different GHGs require different, regionally distinct abatement strategies. As noted by the authors themselves, a strong limitation of this study is the lack of an uncertainty analysis, which would be required due to uncertainties in both emission maps and MRIO data and model.

Also Hubacek, Baiocchi, Feng, Muñoz Castillo, et al. (2017) picked up on the notion of inequality in carbon. The authors applied MRIO data from the Eora database in conjunction with household consumption data from the World Bank's Global Consumption Database, Eurostat, and the US Bureau of Labor Statistics. Because of their different classifications, the expenditure groups used in the household consumption datasets were aggregated into quintiles. Consumer expenditure categories were then linked to the MRIO sectors using bridge matrices, details for which are included in Hubacek, Baiocchi, Feng, and Patwardhan (2017). Following the standard Leontief model, consumption-based carbon footprints were calculated for 186 countries in the base year 2010. The authors show that the carbon footprint increases with higher incomes, i.e. 1.6 tCO_2e per day for the lowest income category, but 17.9 tCO_2e per day for the highest income category. Put differently, 10% of the population are responsible for 34% of the total household carbon footprint, while the poorest 50% of the population are accountable for only 15%. Moreover, the carbon footprints of the US and European countries are less spread than the ones of developing countries. While the household carbon elasticities of income vary significantly between countries, the authors reported that, for developing countries, a doubling of the GDP per capita results in a 4% decrease in elasticity, i.e. a decrease in the carbon footprint. These results emphasise the importance of further examining within- and between-countries carbon inequalities.

Cities and carbon

Compared to the concept of carbon hotspots proposed by Kanemoto et al. (2016), Wiedmann et al. (2016) rather went onto the micro-scale and, away from maps in their geographic meaning (as opposed to Chen et al., 2018), tabularly spatialised carbon footprints for certain supply chains in cities with the example of Melbourne. As summarised by the authors, a plethora of city carbon footprint studies had been published earlier (including Minx et al. (2013) on UK municipalities, Larsen and Hertwich (2010) on Norwegian municipalities, and Jones and Kammen (2014) on regional entities in the US), yet all of them bore two major limitations: not accounting for differences in sectoral greenhouse gas (GHG) emission intensities within and outside the city boundaries, and the missing link between GHG emissions and intermediate demand. The authors therefore proposed the concept of a city carbon map that splits the city's total carbon footprint into industry sectors and product groups, with the former being emission sources and the latter being emission embodiments. It is noteworthy that such a carbon map can only be produced per one final demand category at a time, not across the total final demand simultaneously. Direct household emissions are excluded. The authors noted that it may be preferable to base a city carbon map on supply and use tables compared to symmetric input-output tables (IOTs), with the city's tables nested in a multi-regional framework, and that monetary, physical, or mixed-unit data can be used. The exemplified city carbon map for Melbourne was created for the year 2009, with data derived from the IELab (Lenzen et al., 2014). It shows that scope 2 (40%) and scope 3 (43%) emissions, i.e. emissions occurring outside the city boundaries, were the largest contributors to the total carbon footprint of 100 Mt carbon dioxide equivalents, with households being the main culprits (64%). Moreover, per capita emissions in the sectors goods, electricity, construction, and business, are highest overall. Utilising this concept of a city carbon map for other cities around the globe is mainly limited by the lack of city-scale IOTs, as the authors note. Another restriction of this method is that it does not account for direct emissions from households.

City-level emissions were also the focus in the study on spatially explicit carbon footprints by Moran et al. (2018). Given that so far only many national, few subnational, and several single city carbon footprints were available, the authors calculated regionalised carbon footprints on a global scale. That is, the applied gridded model estimates carbon footprints for cities, towns, and rural areas via gridded population and income data as well as national or subnational MRIO data. In a multi-step procedure, national carbon footprints were broken down to grid cell level. First, national consumption-based carbon footprints were calculated for each country, based on the standard Leontief demand-pull calculus, and using the Eora MRIO database. Sector classifications were matched using bridge matrices. Then, these national footprints were split up, employing subnational carbon footprints for the EU, UK, USA, Japan, and China from other studies. Thereafter, expenditure pattern data from Eurostat, the US Bureau of Labour Statistics, and the World Bank were used to further divide the carbon footprints into urban vs rural ones. Finally, these split carbon footprints were allocated to grid cells using a gridded population model and data on purchasing power. It is shown that cities contribute considerably to the total carbon footprint, both in totals and per capita, and that there is a mismatch of population-footprint shares – about 40% of the global population are responsible for 80% of the total carbon footprint. Hotspots of emission totals can be identified in rich European and US cities as well as in dense middle- and upper-income cities in Asia. Interestingly, however, about a fifth of the top 200 cities lie in countries with low total and per capita emissions, like Cairo or Lima. Moreover, it is not the fastest growing cities that are emission hotspots, but rather the ones with modestly high growth rates. Cities with the highest carbon footprints are Seoul, Guangzhou, and New York. The authors outline as limitations the difficulty of defining city boundaries and statuses, as well as a missing supply chain analysis.

One of the source-studies used in this article on city carbon footprints by Moran et al. (2018) was the one by Jones and Kammen (2014). As one of the few studies deploying a large-scale bottom-up approach, Jones and Kammen investigated the spatial distribution of carbon footprints related to final demand of US households, which was divided into various categories, here called activities. Examined activities were transportation, goods, food, services, and housing; the latter of which included a further disaggregation into electricity, natural gas, other fuels, water, waste, and construction. Household carbon footprints for each activity were calculated by multiplying consumption, measured in either monetary or physical units, by the average emissions per unit of consumption. Summing these carbon footprints per activity yielded total carbon footprints per individual or population. A multitude of data sources was required to compute these footprints, including but not limited to surveys on energy consumption, household travels, and consumer expenditures, as well as the US census. GHG emission factors were also retrieved from multiple sources. Maps showing carbon footprints per household by zip code tabulation area revealed that the Midwest, parts of the South, and parts of the Northeast were specially carbon intensive in the housing activity, particularly regarding electricity, while the carbon footprints for other activities were less concentrated. Total footprints also showed no clear regional pattern. However, it is noteworthy that suburban areas tend to have higher carbon footprints, overall accounting for about 50% of the national household carbon footprint. The total household carbon footprint accounts, moreover, for about 80% of the total US GHG emissions. Except for the 100 largest urban core cities, no correlation between population density and household carbon footprint was found, although a net effect in an inverted u-shape can be identified, i.e. the carbon footprint decreases from a certain population density threshold on. A regression analysis found the number of vehicles per household, annual household income, carbon intensity of electricity, and the number of rooms to be the best explanatory variables. Yet, regional differences must be acknowledged when comparing carbon footprints across regions. A similar study applying a bottom-up approach for calculating carbon footprints on a large scale was conducted one year earlier by Minx et al. (2013) on municipalities in the UK. It showed that about 90% of these are carbon net importers and that the individual carbon footprints are mainly driven by socio-economic factors.

The ecological footprint

With a more direct reference to nature compared to other footprint types, the concept of ecological footprints was developed by Wackernagel and Rees (1998) and estimates the land area that is required to meet human demands. It is measured in global hectares, with a global hectare being equal to one hectare of biologically productive land area with a global average productivity for a specified year (Wackernagel & Rees, 1998). Since then, this concept has been applied and further improved by a multitude of studies (among others: Simmons et al., 2000; Lenzen & Murray, 2001; Barrett & Scott, 2003; Erb, 2004).

Also Wiedmann et al. (2006) built on this approach and developed a method that allows the disaggregation of impacts. This is achieved by re-allocating national ecological footprint accounts to household consumption activities reflected in input-output analysis. Footprints were calculated for the United Kingdom in 2000, revealing that the highest footprints can be allocated to household consumption, capital investment, and exports. Applying the COICOP sector classification (United Nations Statistics Division, 2018), the results for household consumption show the highest total ecological footprints and total ecological footprint per expenditure in the food and energy sectors, followed by “other recreational items and equipment”. Based on their results, Wiedmann and colleagues argued that standardised national accounts including ecological footprints would allow for systematically evaluating policy options.

Based on the concept of ecological footprints by Wackernagel and Rees (1998; see also Galli et al., 2014) in general, and the one combined with IO developed by Wiedmann et al. (2006) in specific, Ewing et al. (2012) brought their ecological footprints into a multiregional context by extending traditional ecological and water footprint methods via MRIO. Doing so required the calculation of bioproductive area/volume appropriation per product, country, and type, after which physical demand matrices were transformed into product-based monetary column vectors. These vectors were then normalised by the total output and multiplied by the Leontief inverse and the direct requirements associated with the monetary final demand. Opposed to that, the authors also suggested a hybrid approach. This calculates the land, ecological, and water footprints by multiplying the land/water appropriation by the physical production data and the use of physical products associated with a given final demand. The latter is based on multiplying the use of physical products normalised by the total output by the Leontief inverse and the final demand. The main advantage of the second approach is the possibility of analysing the pressures along supply chains via, for instance, structural decomposition analysis, contribution analysis, or structural path analysis. However, this method also bears limitations, particularly regarding data availability and uncertainty. Despite its shortcomings, though, the approach presented in this study opens up new ways by harmonising footprint methodologies and preserving sectoral detail, both on multi-regional level. This method of MRIO footprints was then further applied by, for instance, Steen-Olsen et al. (2012) for the European Union, Weinzettel et al. (2013) on global trade, and Baabou et al. (2017) for selected Mediterranean cities. The latter study also gives a succinct overview of city-level ecological footprint approaches, e.g. the bottom-up approach for Shenyang in China and Kawasaki in Japan by Geng et al. (2014) or the top-down approach for Santiago de Chile by Wackernagel (1998).

With the purpose of finding the method that suits the needs most, Hanafiah et al. (2012) compared ecological and biodiversity footprints for 1340 products and services, aggregated into 13 product groups, yet without any ties to EE-MRIO. The authors focused on impacts from land use and carbon dioxide emissions. While the ecological footprints for both land use and CO2 emissions are based on equivalence factors for certain land use or emission types, the biodiversity footprints for these two impact categories are based on the loss of mean species abundance, the latter being the ratio of species abundance in an actual versus undisturbed ecosystem (Alkemade et al., 2009). Per definition, the ecological footprint, as also used in this study, refers to the biologically productive land area that is required to meet human needs (Wackernagel &

Rees, 1998), whereas the biodiversity footprint refers to biodiversity loss. Due to the differing nature of these two concepts, only a relative comparison of the two footprints across the impact categories within and across sectors was possible. Both ecological and biodiversity footprints on forest area were highest in products related to biomass energy as well as paper and cardboard. Agricultural products had, as a matter of course, the highest footprints on land used for agriculture. The relevance of CO_2 emissions across all products increased significantly when extending the time horizon. Uncertainty related to equivalence factors and mean species abundance values was not accounted for in this study. Moreover, the concept of mean species abundance itself can be seen as a limitation, since it only gives information about the average response of species per ecosystem (Alkemade et al., 2009), thus lacks detail about ecosystem functioning and species statuses regarding, for instance, endemism or vulnerability. Furthermore, other important impact categories were neglected, e.g. water stress or ecotoxicity.

A detailed discussion of the standard MRIO method (e.g. Wiedmann et al., 2006; Ewing et al., 2012) and the hybrid MRIO approach (Ewing et al., 2012) compared to process analysis, i.e. the traditional ecological footprint method (Wackernagel & Rees, 1998; Galli et al., 2014), is provided in Weinzettel et al. (2014). There it is shown that each approach is not equally suitable for various tasks. The authors argue, however, that, provided increased product detail and data availability, the hybrid MRIO approach may be preferable. As for the ecological footprint per se, one must note the critique towards its legitimacy and quality as outlined in the discussion paper by Galli et al. (2016).

The footprint family

Multiple studies aimed at examining the compatibility of different environmental footprints. Following the idea of integrating these into a "footprint family", Galli et al. (2012) defined the latter as a set of indicators, namely the ecological footprint, the carbon footprint, and the water footprint, each of which quantifies human pressure on the environment per respective impact category via consumption-based accounting. While Čuček et al. (2012) gave an overview of footprints per se, i.e. distinguishing between environmental, social, economic, hybrid, and composite footprints, Fang et al. (2014) provided an overview of studies that compared or integrated footprints, showing that the carbon, ecological, energy, and water footprint techniques were the most prominent ones. Fang et al. (2014) evaluated and compared these four methods and suggested to integrate them into a "footprint family". Dimensions and scales, e.g. regarding the choice of impact vs pressure footprint, would then still have to be defined depending on the study's purpose (Fang et al., 2016).

In comparison to that, the European Union suggested a different set of complementary indicators, namely on water, land, materials, and carbon resources (European Commission, 2011). This was then picked up by Tukker et al. (2016) who calculated footprints within these domains for the base year 2007 through an MRIO approach using EXIOBASE version 2.1, showing that countries with high per capita Gross Domestic Product generally have higher per capita footprints. While it was outlined that China and the Asia-Pacific region exhibited high absolute footprints, Europe was described as being an important driver of these emissions and resource uses (Tukker et al., 2016). Also Ivanova et al. (2016) covered the four environmental domains of carbon, water, land, and material, and outlined that the footprint shares of household consumption are higher than those of all other final demand categories. Moreover, Ivanova et al. (2016) found that the environmental multipliers were highest for the consumption categories food (land, water, material) and mobility (carbon), for which simultaneously the expenditure per capita was lowest per domain.

Spatially explicit biodiversity threats

Despite the above listed assessments of environmental pressures, and although it had been shown earlier that economic activities are a driver of habitat degradation (for example: Nepstad et al., 2006; Koh & Wilcove, 2007; Philpott et al., 2008), a quantification of the biodiversity loss attributable to international trade had been missing. Lenzen, Moran, et al. (2012) developed a novel method for analysing this cause-effect relationship. Based on threat lists from the IUCN Red List of Threatened Species and BirdLife International, threat causes for endangered, critically endangered, and vulnerable species were attributed to one or more culpable industry sectors via a binary concordance matrix. Illegal activities remained unaccounted for, while effects of climate change were evenly attributed to all sectors worldwide. Normalising the concordance matrix prevented double-counting the threat causes. In addition, these threat causes were weighted equally due to data deficiency. Having this biodiversity data integrated into the MRIO data sourced from the Eora MRIO database and then applying Leontief's (1970) standard input-output calculus, yielded biodiversity footprints that quantify direct and indirect effects of final consumption expenditure on biodiversity. These footprints in combination with a further structural path analysis revealed that up to 30% of biodiversity threats were caused by international trade, particularly by the demand of consumers in developed countries for commodities produced in developing countries. That is, many western countries are net importers of species threats while many developing countries are shown to be net exporters of species threats. Despite its thoroughness, this study still holds limitations that are mainly due to unavailability of data, e.g. country attribution problems of threats to marine fish and migratory bird species, missing weighting of threat severities, or distorted economic data for regions without the possibility of adequate national accounting. Apart from that, it must be noted that this study only considered threatened species, i.e. the human impact on biodiversity that is not above the thresholds set by the IUCN was not accounted for.

Applying this biodiversity footprint method by Lenzen, Moran, et al. (2012), Moran and Kanemoto (2017) mapped species threat hotspots based on combined extent-of-occurrence (EOO) maps for threatened species and regional consumption demand. Required economic data was retrieved from the Eora global MRIO database, while species information was retrieved from IUCN and BirdLife International. Here again, only species listed as vulnerable, endangered, or critically endangered, and for which the threats can be directly attributed to legal economic activities, were considered. Hence, threats from diseases, invasive species, illegal economic activities, and similar, were neglected. In case of multiple threats for a single species, all threats were weighted equally. Similarly, every individual species was weighted equally. Overlaying the EOO maps and linking them with the global trade model revealed that the biodiversity footprints were highly concentrated, i.e. large shares of the respective total impacts lay in relatively small areas. Given the example of US consumption, threat hotspots could be identified in southeast Asia, central Asia, southern Europe, the Sahel, central America, along the Amazon river, in the Brazilian highlands, as well as in southern Canada. The authors pleaded for shared responsibility among producing and consuming countries, including international trade, and suggested employing spatial supply chain analysis, as done in their study, for directing conservation efforts. Apparent limitations of the study are the potential overestimates of the hotspots, that only terrestrial and near-shore marine species were considered, that spatialised species density models could be preferable for marine biodiversity, that threat hotspots of birds based on EOO differ from such based on other parameters, and that the analysis was based on historical records and not on current nor emerging threats.

Biodiversity impacts measured differently

Another way of calculating biodiversity footprints was presented by Wilting et al. (2017), who applied EE-MRIO and used the metric of mean species abundance losses per hectare land. Economic data was retrieved from WIOD and supplemented by data from GTAP, covering overall 48 industries across 40 countries and five world regions for the year 2007. Data on environmental pressures from land use and GHG emissions were aggregated from multiple source databases and, in case, reconciled to make it available for the base year. Pressures from land use and infrastructure were, in addition, allocated to sectors and/or consumers according to their impact pathways. All pressures were then converted into impacts via biodiversity loss factors. These biodiversity loss factors were based on mean species abundance losses and were further transformed depending on the impact category. The final biodiversity footprint combined actual losses due to land use with potential future losses due to GHG emissions. Hence, the overall footprint did not represent only actual losses in a specified year; however, these actual and future losses are conditioned by pressures in a specified year. The total footprints were highest in North America and Europe, while the per capita footprint was by far highest in Oceania. Europe and North America, as well as Japan were, moreover, net biodiversity loss importers. Global biodiversity loss was dominated by direct and indirect land use with 66%. Food consumption was generally the economic category with the highest footprint (about 40%), with poorer countries having higher shares of biodiversity losses in that category than wealthier ones. Moreover, the share of foreign biodiversity losses was smaller in larger countries, e.g. Brazil, China, and Russia, although indirect land use impacts were higher there. It was found that per-capita expenditure as a measure of wealth and population density as a proxy for resource use efficiency explain the biodiversity footprint variation across regions best, with affluence showing overall positive relationships.

Also Kitzes et al. (2017) calculated biodiversity footprints using MRIO, which they called “wildlife footprints”. More specifically, they focused on birds as indicators for biodiversity as a whole, using two metrics: occupied bird ranges and missing bird individuals. While the former is a map-count of the number of present-day breeding bird ranges, the latter compares the number of wild breeding birds in an intact habitat to breeding bird densities in each vegetation type estimated through surveys. Both metrics were combined in map format with a map of the human appropriation of net primary productivity (HANPP); HANPP is the aggregated impact of land use on the availability of net primary productivity in ecosystems per year (Haberl et al., 2007). HANPP maps were first disaggregated into four types of land uses and then area-based weighted. Combining the resulting data with economic data from GTAP, wildlife footprints driven by consumer purchases across 57 sectors in 129 regions were calculated. The total global wildlife footprint was estimated as 26±13 billion missing birds, or 4.3 billion km² of occupied bird ranges. On a country level, the authors show that these footprints are highest in regions with large human populations and economies, e.g. the US, India, and China. Particularly food production and consumption drive these footprints; here it must be considered, however, that only human impacts through land use were accounted for. Moreover, one must be cautious when interpreting these wildlife footprints, as only birds and not the total biodiversity is accounted for. Technical limitations arise from the available maps, i.e. bird density, breeding bird range, and HANPP maps. In addition, the level of sectoral and spatial coverage is limited by the choice of MRIO database.

The biodiversity accounts developed by Chaudhary and colleagues in a series of three studies relied on the Countryside species-area relationship (Chaudhary et al., 2015; Chaudhary & Kastner, 2016; Chaudhary et al., 2016). More specifically, local land occupation characterisation factors (CFs) were calculated using the latter relationship, which were then allocated to different land use types based on their relative area share. Regional land occupation CFs for each land use type were then derived by dividing the marginal species loss by the marginal increase in occupied area. Multiplying the latter CFs by half of the respective regeneration time per land use type yielded regional land transformation CFs. Eventually, global CFs could be calculated by weighting the regional ones with vulnerability scores; the required vulnerability scores per ecoregion were derived through the ratio of threatened endemic richness per total species richness. Summing the product of CFs and harvested area and dividing this by the sum of the total annual production, both per crop type and pixel, yielded the impact per ton of each crop. The biodiversity impact per country, however, was derived by summing the product of weighted CF and area per land use type and pixel. It was found that impacts on mammals were particularly high in South-East Asia and Madagascar, as well as in Central America. Moreover, differences of scale between regional and global impacts were identified. Overall consumption impacts were highest in India, Indonesia, and China, while exported impacts were by far highest for Indonesia and imported impacts were highest in the USA and China. Major causes for these impacts were the cultivation of rubber, cocoa, coffee, palm oil, and similar agricultural products. The strength of this bottom-up approach is the spatial explicitness, which is adopted in the present study; on the downside, only biodiversity impacts due to land use can be accounted for.

From pressures to impacts via MRIO and process analysis

According to the DPSIR framework (drivers, pressures, state, impact, responses; Smeets & Weterings, 1999), most of the studies described above estimated environmental footprints based on the linkage between drivers, i.e. human consumption, and environmental pressures, i.e. resources use and emissions (for example: Tukker et al., 2016; Ivanova et al., 2017). Few attempted to link drivers to the environmental state (for example: Lenzen, Moran, et al., 2012;

Moran & Kanemoto, 2017), and only one of these studies actually linked drivers to impacts (Wilting et al., 2017). However, for adequate policy responses, the impacts of human consumption must be assessed, so that impact footprints are preferable in an environmental policy perspective.

Based on this critique of traditional footprints, Verones, Moran, et al. (2017) developed a novel methodology that not only linked drivers to impacts, but even combined the MRIO approach with process analysis metrics. The so-called ecosystem impact footprints were calculated combining the Eora MRIO supply chain database and the LC-Impact LCIA model (Verones et al., 2018). 13 types of pressures were accounted for, following 8 distinct impact pathways (climate change, marine and freshwater eutrophication, terrestrial acidification, water and three types of land use) in marine, freshwater, and terrestrial ecosystems. PDF was chosen as a metric, considering damage on species richness as a proxy for biodiversity; additionally, PDF also accounts for species vulnerability (as the result from level of endemism) within LC-Impact. The highest total ecosystem footprints had: USA, China, Brazil, India, and Japan. Impacts from land occupation (66%), water stress, and climate change accounted for 99% of the modelled impacts. Similar pressure on ecosystems with different resource availability and/or species richness lead to different impacts at the national level. Moreover, it became clear that ecological impact is not equivalent to resource use. The study made claims against the correctness of the hypothesis of ecologically unequal exchange (Emmanuel, 1972; Moran et al., 2013), since pressure footprints and impact footprints differ in their magnitude and relative distribution in spatial comparison. A potential underestimation of the impacts was mentioned. Moreover, synergistic effects were neglected.

Refining and disaggregating an MRIO model with CES

While MRIO is in general a suitable method for analysing both national and regional footprints across different sectors, currently available MRIO databases do not provide a sufficient level of detail for examining the final demand further, in particular the household final demand, in order to identify major sources of impacts. Such a disaggregation of final demand would, however, allow for analysing effects of different socio-economic variables and other factors. Apart from bottom-up approaches like the one by Jones and Kammen (2014), also top-down MRIO approaches can achieve this, when combining highly detailed data from consumer expenditure surveys (CES) with MRIO data. Steen-Olsen et al. (2016) did exactly this to calculate carbon footprints of Norwegian household consumption for the year 2012 and outlined its development since 1999. As the authors indicated, combining MRIO and CES was already done in earlier studies, with Herendeen and Tanaka (1976) on US household energy requirements being one of the earliest ones.

Steen-Olsen et al. (2016) provide a detailed description of how to reconcile CES data with input-output tables, which was performed similarly by Ivanova et al. (2017) on a European level. This multistep procedure goes as follows: Due to differing year coverage of the data sources, a price conversion via the consumer price index and, if necessary, exchange rate information was required to adjust for potential price changes across years. Doing so also required a product classification bridging from the price indices to that of the CES. The annual household expenditures were then scaled up to the national level by multiplying them by the total number of households per year. Thereafter, underreporting of CES compared to the MRIO data was accounted for by comparing the total expenditure in the base year to the Norwegian household final demand; the underreported fraction was assumed to be constant over time and appended to the CES matrix. The different product sector classifications were then aligned via concordance matrices, thus yielding adjusted final demand vectors. The last step of CES data reconciliation was the transformation of final demand from purchasers' to basic prices, based on EXIOBASE product-wise information on transport margins, taxes, and subsidies. The final demand per product and supplying region for a given year was then derived by re-distributing import shares. Through the standard MRIO approach and with data from EXIOBASE, Steen-Olsen et al. (2016) calculated carbon footprints for Norwegian households in 2012, yielding an average 22.3 tonnes carbon dioxide equivalents per household. Food, transport, and housing were found to be the sectors contributing most to the household carbon footprint, with the multiplier for transport being more than thrice the one for housing. It is noteworthy that, although 70% of value-added were generated within Norway, 60% of greenhouse gases related to Norwegian household consumption were emitted outside its country boarders. Moreover, higher income groups generally show higher carbon footprints. Additionally, an overall increase of 25% of the carbon emissions was shown for the period 1999 – 2012. The low level of product-detail was found to be the most important limitation of this IO-based study.

Ivanova et al. (2017) made even more use of CES data and not only tried to explain footprints through different expenditure deciles as Steen-Olsen et al. (2016) did, but also through other socio-economic variables like income or household size, geographic factors such as temperature, and also the electricity mix intensity as a technical component. Their study is in line with other carbon footprint analyses, yet with a regional focus and it combines regionalised consumption expenditure survey (CES) data provided by Eurostat (2015) with environmental and trade data from EXIOBASE. Data reconciliation was essential for matching CES with MRIO data, and was exercised similar to how Steen-Olsen et al. (2016) did it. Applying Leontief's (1936, 1970) standard input-output calculus yielded carbon footprints associated with household consumption for 177 regions in 27 EU-countries in the year 2007. It was shown that certain regions had a considerably higher carbon footprint than others, i.e. in total (e.g. Bavaria in Germany, Lombardy in Italy, or the Parisian region in France) and per capita (particularly in the UK and Ireland, followed by central European regions, Finland, and Greece). Overall, emissions attributable to transport and housing are highest, accounting together for about 50% of EU's total carbon footprint. A regression model including a relative weights analysis and cluster robust errors revealed that income has the strongest causal relationship with the regional carbon footprints, particularly in income-elastic sectors like transportation. Moreover, it is shown that inter-regional income equality and emission ranges correlate across countries. Due to missing uncertainty information on the CES data, no uncertainty analysis was possible. Another limitation of this study is a potential systematic bias due to a lack of regionalised product intensities as well as the non-uniform behaviour across countries of the combined data.

The way to go

In this literature overview, various publications on the assessment of environmental burdens using MRIO or similar approaches are presented. Two major developments can be identified: the increasing relevance of cities and modern lifestyles regarding sustainable consumption, and the move from pressure accounts to impact-based assessments. The combination of MRIO data with CES data allows for the disaggregation of household final demand according to distinct socio-economic variables and thus enables an examination of the link between such characteristics and the connected environmental consequences. The extension of an MRIO model with additional metrics, e.g. derived from life cycle impact assessment, follows the call for a progression from pressure to impact footprints. The combination of both these points is currently not covered in the relevant literature. The present study takes a step into the direction of closing this research gap.

SI3. Multi-Regional Input-Output Databases

Several databases exist that contain environmentally extended inter- or multi-regional input output data, all of which are equipped with various environmental extensions on e.g. GHG emissions, land occupation, water requirements, or labour. Although all these databases differ in many aspects, they have the difficulty of data integration and harmonisation in common (Tukker & Dietzenbacher, 2013). The largest differences, obvious to the user, lie in the sectoral and geographic coverage, ranging from only a handful of countries with a couple of dozen sectors to global coverage with several hundreds of sectors per country. Key facts on these databases are outlined below and in Table S1.

The MRIO database with the lowest country detail is the Asian International Input-Output tables (AIIOTs) that has a focus on Asian countries and covers data back until 1975 (Meng et al., 2013). In stark contrast to that, Eora offers high spatial detail through its 190 countries and a total of 15,909 sectors (Lenzen, Kanemoto, et al., 2012; Lenzen, Moran, Kanemoto, et al., 2013). Another database with high spatial detail is the Global Trade Analysis Project (GTAP), that covers 57 sectors each in 140 countries for the reference years 2004, 2007, and 2011 (Aguiar et al., 2016). When it comes to the highest sectoral detail per country, EXIOBASE is the choice to go for with 163 industries by 200 products across all the 44 countries (EU28 plus 16 major economies) and 5 rest of the world (RoW) regions for the period 1995 – 2011 (Tukker et al., 2013; Wood et al., 2015; Stadler et al., 2018). A similar spatial coverage is provided by the World Input-Output Database (WIOD) with 56 sectors each in 43 countries plus RoW for the period 2000 – 2014 (Timmer et al., 2015). While most of the above databases are at least partly sourced by trade data provided by the Organization for Economic Cooperation and Development (OECD), the following two databases rely mainly on it: the Inter-Country Input-Output Database (ICIO; Wiebe & Yamano, 2016) and the related Global Resource Accounting Model (GRAM; Giljum et al., 2008; Bruckner et al., 2012; Wiebe et al., 2012), that covers 48 sectors across 53 countries and two world regions.

Apart from these differences in coverage detail, also the construction methods of the databases differ. This results in the databases giving slightly different accounts per sector and country, e.g. because one database focuses solely on the correct representation of trade detail (e.g. GTAP), while another one aims to represent the national SUTs or IOTs correctly (e.g. Eora). Details on that can be found on the respective database websites and the referenced publications.

Tukker and Dietzenbacher (2013), as well as Inomata and Owen (2014) provided fairly broad overviews of these global MRIO tables, outlining their construction, strengths, and weaknesses, although in their earlier versions. A short summary of the key facts of these databases can be found in Wiedmann et al. (2011). Due to differences between the databases, discrepancies when comparing results calculated with these databases can be expected (Arto et al., 2014; Geschke et al., 2014; Inomata & Owen, 2014; Moran & Wood, 2014; Owen et al., 2014; Owen et al., 2016; Wieland et al., 2018).

A list of regions covered by EXIOBASE is shown in Table S2.

Table S1: Overview of major global EE-MRIO databases. Updated from Tukker and Dietzenbacher (2013)

Database name	**Countries**	**Type**	**Detail (*i x p*)[1]**	**Time**
AIIOTs	Asia-Pacific (1975: 8; 1985 – 2005: 10 + BRICS)	MR IOT	56 x 56 (1975) 78 x 78 (1985 – 1995) 76 x 76 (2000, 2005)	1975, 1985, 1995, 2000, 2005
Eora	World (190)	MR SUT/IOT	26 to over 400 sectors (country-specific) 26 x 26 (aggregated)	1970 – 2015 with a time series starting from 1990
EXIOBASE	World (44 + 5 RoW)	MR SUT	163 x 200	1995 - 2011
ICIO/GRAM	World (ICIO: 65 + 2 ROW regions; GRAM: 53 + 2 world regions)	MR IOT	34 x 34 (ICIO) 48 x 48 (GRAM)	1995 - 2011
GTAP	World (140 countries)	MR IOT	57 x 57	2004, 2007, 2011; bilateral trade data for 1995 - 2013
WIOD	World (43 + RoW)	MR SUT	35 x 59	1995 – 2014

[1] *i* = industries, *p* = products

Table S2: Regions covered by EXIOBASE

Code	Name	Code	Name
AT	Austria	SI	Slovenia
BE	Belgium	SK	Slovakia
BG	Bulgaria	GB	United Kingdom
CY	Cyprus	US	United States
CZ	Czech Republic	JP	Japan
DE	Germany	CN	China
DK	Denmark	CA	Canada
EE	Estonia	KR	South Korea
ES	Spain	BR	Brazil
FI	Finland	IN	India
FR	France	MX	Mexico
GR	Greece	RU	Russia
HR	Croatia	AU	Australia
HU	Hungary	CH	Switzerland
IE	Ireland	TR	Turkey
IT	Italy	TW	Taiwan
LT	Lithuania	NO	Norway
LU	Luxembourg	ID	Indonesia
LV	Latvia	ZA	South Africa
MT	Malta	WA	RoW Asia and Pacific
NL	Netherlands	WL	RoW America
PL	Poland	WE	RoW Europe
PT	Portugal	WF	RoW Africa
RO	Romania	WM	RoW Middle East
SE	Sweden		

SI4. CES data reconciliation

The reconciliation of data from Eurostat's consumer expenditure survey was a major step in the present study. Guidance on this was provided by Alexandre Tisserant (2018) from the Industrial Ecology programme at NTNU. The procedure and notation follow to a large extent the data reconciliation approaches by Steen-Olsen et al. (2016) and Ivanova et al. (2017).

Socio-economic variables that are considered in this study are degree of urbanisation (DEG), income quintiles (INC), age groups (i.e. age of the reference person, who is the main income earner; AGE), and types of households (TYP). Of these variables, DEG is of primary interest, since it allows analysing the role of urbanisation in consumption-based accounts. The variables INC, AGE, TYP were chosen as additional ones, because data are available for all required factors, i.e. among others the consumer expenditure structure and mean consumer expenditure. Each variable is distinguished into various parameters (Table S3). Parameters denoted as unknown are left out in the course of data reconciliation due to the data availability regarding other variables that are included at later stages. An overview of the country coverage per socio-economic variable is provided in Table S4 for year 2010 and in Table S5 for year 2005 at the end of this section. While the definitions of the variables INC, AGE, and TYP are self-explanatory, it must be noted for the variable degrees of urbanisation that these are differentiated according to the population density in grid cells (Eurostat, 2018a; cf. SI11): DEG1 are densely populated areas (also referred to as cities or large urban areas); DEG2 are intermediate density areas (also referred to as towns and suburbs or small urban areas); and DEG3 are thinly populated areas (also referred to as rural areas). For more details, the reader is referred to the Eurostat definition.

Table S3: Socio-economic variables and associated parameters.

Variable	DEG	INC	AGE [years]	TYP
Parameters	▪ DEG1 (Cities) ▪ DEG2 (Towns) ▪ DEG3 (Rural) ▪ Unknown	▪ Q1 (1st quintile) ▪ Q2 (2nd quintile) ▪ Q3 (3rd quintile) ▪ Q4 (4th quintile) ▪ Q5 (5th quintile)	▪ Y_LT30 (<30) ▪ Y30x44 (30 – 44) ▪ Y45x59 (45 – 59) ▪ Y_GE60 (>60) ▪ Unknown	▪ A1 (Single person) ▪ A1_DCH (Single person with dependents) ▪ A2 (Two adults) ▪ A2_DCH (Two adults with dependents) ▪ A_GE3 (Three or more adults) ▪ A_GE3_DCH (Three or more adults with dependents) ▪ Unknown

Eurostat's CESs cover the years 1988, 1994, 1999, 2005, and 2010 (Eurostat, 2015). Data for 2015 was also available, yet only for a few countries; therefore, and because no MRIO data is available for this year, 2015 was excluded from the analysis. It is important to note that the country and year coverage differ between the entries in the dataset. For example, there is no data available on income quintiles in Italy or Luxembourg for the year 2010. In cases of such data deficiency, data for the year prior to the base year was considered, as it was assumed that the structure of consumption expenditure would vary only negligibly between the distinct periods (the mean expenditure is in that case only of minor importance as a rescaling to MRIO final demand takes place at a later step anyway). For this study, only 2010 and 2005 datasets were used. Hence, if also for 2005 no data was available, no further substitution was afforded. A rescaling of 2005 values to the 2010 levels (for 2010 calculations) via price indices was not computed due to time constraints, but it acknowledged as one limitation.

As a first step of the CES data reconciliation, the mean consumption expenditure per household $\boldsymbol{E}_{c,i}^{mean,hh}$ is upscaled to the national level $\boldsymbol{E}_{c,i}^{mean,national}$, whilst preserving its structure (equation 2). $\boldsymbol{E}_{c,i}^{mean,hh}$ is given per country c and for each socio-economic variable i, i.e. it is a row-vector of size $1 \times p$, with p denoting the number of parameters per variable. Hence, the number of households per country, variable, and respective parameter $\boldsymbol{\beta}_{c,i}$ is required, which is derived by the element wise multiplication of the total number of households per country $\boldsymbol{h}_c$ by the $1 \times p$ sized distribution (in %) of households per country and variable $\boldsymbol{\delta}_{c,i}$ (equation 1; see Tables 5 and 6 for the total number of households per year). In the case of variable INC, an account of the national number of households per parameter was provided by Alexandre Tisserant, which was rescaled to Eurostat totals (no household distribution was included in the data retrieved from Eurostat).

$$\boldsymbol{\beta}_{c,i} = \boldsymbol{h}_c \circ \boldsymbol{\delta}_{c,i} \tag{1}$$

The actual upscaling of the mean consumption expenditure from per household to national level is achieved by element wise multiplying the per household mean expenditure by the respective number of households:

$$\boldsymbol{E}_{c,i}^{mean,national} = \boldsymbol{E}_{c,i}^{mean,hh} \circ \boldsymbol{\beta}_{c,i} \tag{2}$$

This $1 \times p$ national mean expenditure is balanced thereafter, i.e. disaggregated through an element-wise multiplication by the respective consumer expenditure structure per country and COICOP sector $\boldsymbol{E}_{c,i}^{structure,COICOP}$ of size $l \times p$, with l being the number of sectors (equation 3).

$$\boldsymbol{E}_{c,i}^{balanced,COICOP} = \boldsymbol{E}_{c,i}^{mean,national} \circ \boldsymbol{E}_{c,i}^{structure,COICOP} \tag{3}$$

COICOP stands for "Classification of Individual Consumption according to Purpose" and covers three distinct levels with differing sectoral detail (United Nations Statistics Division, 2018). Data on level 2 of the COICOP classification (groups, 3-digit, 47 categories) was chosen, as country-specific concordance matrices used for sector bridging (cf. equation 7) were provided only for this level – not for the even more detailed levels 3 (classes, 4-digit, 117 categories) and 4 (sub-classes, 5-digit, 303 categories), nor for the aggregated level 1 (divisions, 2-digit, 12 categories). In either case, only the individual consumption expenditure (ICE) of households would be considered, i.e. leaving out the ICEs of non-profit institutions serving households and the ones of general government.

The phenomenon of underreporting has been covered earlier in the literature (Bee et al., 2012; Steen-Olsen et al., 2016). It describes the mismatch between surveyed expenditures and data from national accounts; the underreporting per country (and variable) $\boldsymbol{\varepsilon}_{c,i}^{balanced}$ can be estimated by subtracting the sum of balanced national expenditure $\boldsymbol{E}_{c,i}^{balanced,COICOP}$ across all sectors and parameters from the sum of household final demand in purchasers' prices $\boldsymbol{Y}_{c}^{pp,EXIO}$ across all sectors (equation 4). While the former follows the COICOP level 2 sector classification (47 sectors, *l*), the latter is structured according to the EXIOBASE sector classification (200 sectors, *m*, here shortened to EXIO). The dimensions of $\boldsymbol{Y}_{c}^{pp,EXIO}$ are $m \times 1$.

$$\boldsymbol{\varepsilon}_{c,i}^{balanced} = \sum\nolimits_{m} \boldsymbol{Y}_{c}^{pp,EXIO} - \sum\nolimits_{l,p} \boldsymbol{E}_{c,i}^{balanced,COICOP} \tag{4}$$

The sum of the balanced national expenditure, per country and variable, across the COICOP sectors is then element wise divided by the total balanced national expenditure across sectors and parameters per country and variable, thus yielding the $1 \times p$ structure of the reported expenditures per parameter $\boldsymbol{\vartheta}_{c,i}^{underreported}$ (in %):

$$\boldsymbol{\vartheta}_{c,i}^{underreported} = \sum\nolimits_{l} \boldsymbol{E}_{c,i}^{balanced,COICOP} \oslash \sum\nolimits_{l,p} \boldsymbol{E}_{c,i}^{balanced,COICOP} \tag{5}$$

This structure is thereafter element wise multiplied by the total underreported amount per country (equation 6). Through this procedure, the underreporting per parameter $\boldsymbol{E}_{c,i}^{underreported}$ is derived for all countries and variables, which is then appended to the balanced national expenditure matrix per country and variable, now called $\boldsymbol{E}_{c,i}^{balanced,COICOP+}$ ($48 \times p$). Negative underreporting, i.e. overreporting, was treated as zeros, by that following the reasoning of Ivanova et al. (2017). In the respective .mat-file only the underreporting per parameter is shown as zeros, whereas the total and the relative underreporting are shown in their original values.

$$\boldsymbol{E}_{c,i}^{underreported} = \boldsymbol{\vartheta}_{c,i}^{underreported} \circ \boldsymbol{\varepsilon}_{c,i}^{balanced} \tag{6}$$

To bridge the CES and MRIO product classifications, the appended national balanced expenditure per parameter and sector is then multiplied by a weighted, country-specific bridge matrix $\boldsymbol{W_c}$, also referred to as concordance matrix (equation 7). For details on how to derive an optimal bridge matrix see Steen-Olsen et al. (2016).

$$\boldsymbol{E}_{\boldsymbol{c},\boldsymbol{i}}^{\boldsymbol{balanced},\boldsymbol{EXIO}} = \boldsymbol{E}_{\boldsymbol{c},\boldsymbol{i}}^{\boldsymbol{balanced},\boldsymbol{COICOP+}} * \boldsymbol{W}_{\boldsymbol{c}} \tag{7}$$

This balanced national expenditure is then normalised to one per row by an element wise division by the sum of the balanced national expenditure across parameters and rescaled to the $m \times 1$ MRIO final demand in basic prices $\boldsymbol{Y}_{\boldsymbol{c}}^{\boldsymbol{bp},\boldsymbol{EXIO}}$ through element wise multiplication (equation 8). Detailed accounting for margins, taxes, and subsidies as in Steen-Olsen et al. (2016) and Ivanova et al. (2017) was thus circumvented. The derivation of a reconciled final demand in basic prices is necessary as the emission intensities included in EXIOBASE are given for basic prices.

$$\boldsymbol{Y}_{\boldsymbol{c},\boldsymbol{i}}^{\boldsymbol{balanced},\boldsymbol{bp},\boldsymbol{EXIO}} = \boldsymbol{E}_{\boldsymbol{c},\boldsymbol{i}}^{\boldsymbol{balanced},\boldsymbol{EXIO}} \oslash \sum\nolimits_{\boldsymbol{l}} \boldsymbol{E}_{\boldsymbol{c},\boldsymbol{i}}^{\boldsymbol{balanced},\boldsymbol{EXIO}} \circ \boldsymbol{Y}_{\boldsymbol{c}}^{\boldsymbol{bp},\boldsymbol{EXIO}} \tag{8}$$

Before the by this procedure created household final demand $\boldsymbol{Y}_{\boldsymbol{c},\boldsymbol{i}}^{\boldsymbol{balanced},\boldsymbol{bp},\boldsymbol{EXIO}}$ can be applied for consumption-based accounting using an MRIO model (see section SI6 for details), it needs to be further treated. More specifically, a matrix containing the household final demand of all considered countries must be established. Details on that are described in section SI5.

In addition, also population numbers were calculated per parameter while reconciling CES data, so that per-capita footprints could be calculated for each country and parameter. This was achieved by the element wise multiplication of the $1 \times p$ sized vector of disaggregated number of households $\boldsymbol{\beta}_{c,i}$ (cf. equation 1) by the $1 \times p$ vector of number of persons per household $\boldsymbol{\varphi}_{c,i}$:

$$\boldsymbol{n}_{\boldsymbol{c},\boldsymbol{i}} = \boldsymbol{\beta}_{\boldsymbol{c},\boldsymbol{i}} \circ \boldsymbol{\varphi}_{\boldsymbol{c},\boldsymbol{i}} \tag{9}$$

Table S4: Eurostat data availability for 2010. A cross marks that data is available for the respective category and socio-economic variable; T denotes that only total(s) are available; U denotes that only unknown(s) are available.

Eurostat code	**2010**															
	Consumption expenditure structure				**Mean consumption expenditure (per household and per adult equivalent)**				**Household distribution**				**Persons per household**			
	DEG	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**
AT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
BE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
BG	x	x	x	x	x	x	x	x	x		x	x	x		x	x
CY	x	x	x	x	x	x	x	x	x		x	x	x		x	x
CZ	x	x	x	x	x	x	x	x	x		x	x	x		x	x
DE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
DK	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EA	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EA12	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EA13	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EA17	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EA18	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EEA28	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EEA30	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EFTA	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EL	x	x	x	x	x	x	x	x	x		x	x	x		x	x
ES	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EU15	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EU25	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EU27	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EU28	x	x	x	x	x	x	x	x	x		x	x	x		x	x
FI	x	x	x	x	x	x	x	x	x		x	x	x		x	x

Eurostat code	2010															
	Consumption expenditure structure				**Mean consumption expenditure (per household and per adult equivalent)**				**Household distribution**				**Persons per household**			
	DEG	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**
FR	x	x	x	x	x	x	x	x	x		x	x	x		x	x
HR	x	x	x	x	x	x	x	x	x		x	x	x		x	x
HU	x	x	x	x	x	x	x	x	x		x	x	x		x	x
IE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
IT	x		x	x	x	T	x	x	x		x	x	x		x	x
LT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
LU	x		x	x	x		x	x	x		x	x	x		x	x
LV	x	x	x	x	x	x	x	x	x		x	x	x		x	x
ME		x	x	x	T	x	x	x			x	x			x	x
MK		x	x	x	T	x	x	x			x	x			x	x
MT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
NL	x	x	x		x	x	x	T	x		x		x		x	
NO	x	x	x	x	x	x	x	x	x		x	x	x		x	x
PL	x	x	x	x	x	x	x	x	x		x	x	x		x	x
PT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
RO		x	x	x	T	x	x	x			x	x			x	x
SE	x	x	x		x	x	x	T, U	x		x		x		x	
SI	x	x	x	x	x	x	x	x	x		x	x	x		x	x
SK	x	x	x	x	x	x	x	x	x		x	x	x		x	x
TR		x	x	x	T	x	x	x			x	x			x	x
UK	x	x	x	x	x	x	x	x	x		x	x	x		x	x

Table S5: Eurostat data availability for 2005. A cross marks that data is available for the respective category and socio-economic variable; T denotes that only total(s) are available; U denotes that only unknown(s) are available.

Eurostat code	**2005**															
	Consumption expenditure structure				**Mean consumption expenditure (per household and per adult equiv-alent)**				**Households distribution**				**Persons per household**			
	DEG	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**
AT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
BE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
BG	x	x	x	x	x	x	x	x	x		x	x	x		x	x
CY	x	x	x	x	x	x	x	x	x		x	x	x		x	x
CZ	x	x	x	x	x	x	x	x	x		x	x	x		x	x
DE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
DK	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EA	x	x	x	x	x	x	x	x			x	x	x		x	x
EA12	x	x	x	x	x	x	x	x			x	x	x		x	x
EA13	x	x	x	x	x	x	x	x			x	x	x		x	x
EA17																
EA18																
EE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EEA28	x	x	x	x	x	x	x	x			x	x	x		x	x
EEA30																
EFTA	x	x	x	x	x	x					x	x	x		x	x
EL	x	x	x	x	x	x	x	x	x		x	x	x		x	x
ES	x	x	x	x	x	x	x	x	x		x	x	x		x	x
EU15	x	x	x	x	x	x	x	x			x	x	x		x	x
EU25	x	x	x	x	x	x	x	x			x	x	x		x	x
EU27	x	x	x	x	x	x	x	x			x	x	x		x	x
EU28																
FI	x	x	x	x	x	x	x	x	x		x	x	x		x	x

Eurostat code	2005															
	Consumption expenditure structure				**Mean consumption expenditure (per household and per adult equivalent)**				**Households distribution**				**Persons per household**			
	DEG	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**	**DEG**	**INC**	**AGE**	**TYP**
FR	x	x	x	x	x	x	x	x	x		x	x	x		x	x
HR	x	x	x	x	x	x	x	x	x		x	x	x		x	x
HU	x	x	x	x	x	x	x	x	x		x	x	x		x	x
IE		T			x	x	x	x	x		x	x	x		x	x
IT		x	x	x	x	x	x	x			x	x	x		x	x
LT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
LU	x	x	x	x	x	x			x		x	x	x		x	x
LV	x	x	x	x	x	x	x	x	x		x	x	x		x	x
ME						x										
MK		T			x	x	x	x	x		x	x	x		x	x
MT	x	x	T	x	x	x	x	x	x		x	x	x		x	x
NL		T			x	x	x	x	x		x	x			T, U	T, U
NO	x	x	x	x	x	x			x		x	x	x		x	x
PL	x	x	x	x	x	x	x	x	x		x	x	x		x	x
PT	x	x	x	x	x	x	x	x	x		x	x	x		x	x
RO		T			x	x	x	x	x		x	x	x		x	x
SE	x	x	x	x	x	x	x	x	x		x	x	x		x	x
SI	x	x	x	x	x	x	x	x	x		x	x	x		x	x
SK	x	x	x	x	x	x	x	x	x		x	x	x		x	x
TR		T			x	x	x	x	x		x	x				
UK	x	x	x	x	x	x	x	x	x		x	x	x		x	x

Table S6: Number of households per country, part I (2005 – 2009). A blank field means that no data is available for the respective country and current year. Sources are Tisserant (2018), based on Eurostat (2018b), and SSB (Statistisk sentralbyrå) (2018)

Eurostat Code	2005	2006	2007	2008	2009	Source
AT	3,47E+06	3,51E+06	3,54E+06	3,57E+06	3,60E+06	Eurostat
BE	4,38E+06	4,44E+06	4,44E+06	4,51E+06	4,57E+06	Eurostat
BG	2,87E+06	2,87E+06	2,87E+06	2,88E+06	2,90E+06	Eurostat
CY	2,50E+05	2,52E+05	2,61E+05	2,68E+05	2,70E+05	Eurostat
CZ	4,12E+06	4,14E+06	4,22E+06	4,32E+06	4,37E+06	Eurostat
DE	3,85E+07	3,92E+07	3,93E+07	3,96E+07	3,93E+07	Eurostat
DK	2,35E+06	2,37E+06	2,37E+06	2,42E+06	2,39E+06	Eurostat
ES	1,58E+07	1,62E+07	1,66E+07	1,71E+07	1,74E+07	Eurostat
EE	5,76E+05	5,47E+05	5,46E+05	5,47E+05	5,46E+05	Eurostat
FI	2,40E+06	2,41E+06	2,43E+06	2,45E+06	2,48E+06	Eurostat
FR	2,59E+07	2,62E+07	2,65E+07	2,67E+07	2,70E+07	Eurostat
GB	2,61E+07	2,64E+07	2,66E+07	2,65E+07	2,69E+07	Eurostat
GR	4,22E+06	4,24E+06	4,28E+06	4,29E+06	4,35E+06	Eurostat
HR	1,57E+06	1,57E+06	1,52E+06	1,52E+06	1,52E+06	Eurostat
HU	3,82E+06	3,84E+06	3,88E+06	3,93E+06	3,97E+06	Eurostat
IE		1,48E+06	1,55E+06	1,60E+06	1,66E+06	Eurostat
IT	2,32E+07	2,34E+07	2,37E+07	2,41E+07	2,44E+07	Eurostat
LT	1,18E+06	1,19E+06	1,23E+06	1,37E+06	1,36E+06	Eurostat
LU	1,81E+05	1,85E+05	1,87E+05	1,90E+05	2,02E+05	Eurostat
LV	8,06E+05	8,25E+05	8,35E+05	8,30E+05	8,11E+05	Eurostat
MK		5,27E+05	5,35E+05	5,29E+05	5,39E+05	Eurostat
MT	1,29E+05	1,29E+05	1,31E+05	1,34E+05	1,38E+05	Eurostat
NL	7,01E+06	7,16E+06	7,20E+06	7,21E+06	7,27E+06	Eurostat
NO	2,02E+06	2,05E+06	2,09E+06	2,13E+06	2,15E+06	SSB
PL	1,27E+07	1,28E+07	1,29E+07	1,31E+07	1,33E+07	Eurostat
PT	3,77E+06	3,82E+06	3,84E+06	3,88E+06	3,91E+06	Eurostat
RO	7,36E+06	7,37E+06	7,38E+06	7,38E+06	7,40E+06	Eurostat
SK	1,67E+06	1,71E+06	1,70E+06	1,71E+06	1,76E+06	Eurostat
SI	7,47E+05	7,54E+05	7,45E+05	7,74E+05	7,91E+05	Eurostat
SE					4,25E+06	Eurostat
TR		1,79E+07	1,83E+07	1,87E+07	1,90E+07	Eurostat

Table S7: Number of households per country, part II (2010 – 2014). A blank field means that no data is available for the respective country and current year. Sources are Tisserant (2018), based on Eurostat (2018b), and SSB (Statistisk sentralbyrå) (2018)

Eurostat Code	2010	2011	2012	2013	2014	Source
AT	3,62E+06	3,65E+06	3,69E+06	3,72E+06	3,77E+06	Eurostat
BE	4,62E+06	4,65E+06	4,64E+06	4,64E+06	4,65E+06	Eurostat
BG	2,84E+06	2,78E+06	2,79E+06	2,73E+06	2,76E+06	Eurostat
CY	2,85E+05	2,98E+05	2,95E+05	2,91E+05	2,90E+05	Eurostat
CZ	4,42E+06	4,42E+06	4,47E+06	4,58E+06	4,61E+06	Eurostat
DE	3,96E+07	3,90E+07	3,92E+07	3,94E+07	3,97E+07	Eurostat
DK	2,31E+06	2,32E+06	2,33E+06	2,34E+06	2,36E+06	Eurostat
ES	1,76E+07	1,79E+07	1,81E+07	1,82E+07	1,83E+07	Eurostat
EE	5,49E+05	5,54E+05	5,58E+05	5,56E+05	5,61E+05	Eurostat
FI	2,51E+06	2,53E+06	2,55E+06	2,57E+06	2,60E+06	Eurostat
FR	2,72E+07	2,74E+07	2,77E+07	2,78E+07	2,81E+07	Eurostat
GB	2,72E+07	2,81E+07	2,82E+07	2,76E+07	2,81E+07	Eurostat
GR	4,35E+06	4,34E+06	4,33E+06	4,34E+06	4,34E+06	Eurostat
HR	1,52E+06	1,52E+06	1,52E+06	1,52E+06	1,52E+06	Eurostat
HU	4,01E+06	4,06E+06	4,09E+06	4,11E+06	4,13E+06	Eurostat
IE	1,69E+06	1,69E+06	1,70E+06	1,71E+06	1,71E+06	Eurostat
IT	2,47E+07	2,49E+07	2,52E+07	2,55E+07	2,58E+07	Eurostat
LT	1,35E+06	1,33E+06	1,33E+06	1,31E+06	1,31E+06	Eurostat
LU	2,05E+05	2,11E+05	2,17E+05	2,20E+05	2,25E+05	Eurostat
LV	8,09E+05	8,29E+05	8,33E+05	8,33E+05	8,30E+05	Eurostat
MK	5,44E+05	5,48E+05	5,53E+05	5,55E+05	5,57E+05	Eurostat
MT	1,37E+05	1,39E+05	1,44E+05	1,49E+05	1,50E+05	Eurostat
NL	7,34E+06	7,37E+06	7,45E+06	7,55E+06	7,59E+06	Eurostat
NO	2,17E+06	2,21E+06	2,25E+06	2,27E+06	2,30E+06	SSB
PL	1,33E+07	1,33E+07	1,34E+07	1,37E+07	1,39E+07	Eurostat
PT	3,94E+06	4,00E+06	4,01E+06	4,01E+06	4,06E+06	Eurostat
RO	7,40E+06	7,43E+06	7,42E+06	7,45E+06	7,47E+06	Eurostat
SK	1,75E+06	1,78E+06	1,81E+06	1,81E+06	1,84E+06	Eurostat
SI	8,07E+05	8,30E+05	8,42E+05	8,55E+05	8,62E+05	Eurostat
SE	4,46E+06	4,54E+06	4,59E+06	4,63E+06	4,59E+06	Eurostat
TR	1,93E+07	1,96E+07	2,02E+07	2,07E+07	2,07E+07	Eurostat

SI5. MRIO final demand disaggregation

Before the by country and socio-economic variable disaggregated household final demand could be used for the actual MRIO footprint calculations, it had to be reshaped. More specifically, each country-matrix $\boldsymbol{Y}_{c,i}^{balanced,bp,EXIO}$ had to be brought step-wise onto a block diagonal, and the row dimension of the resulting matrix $\boldsymbol{Y}_{i}^{balanced,bp,EXIO}$ had to be of a size that it could be multiplied by the Leontief inverse **L** (cf. section SI6). Using EXIOBASE with its 49 regions resolution and 200 products per country/region, **L** is of the size *(49 × 200) × (49 × 200) = 9800 × 9800*.

As the CES data reconciliation yielded disaggregated final demand matrices for, depending on the socio-economic variable, about 29 European countries, the total final demand matrix had to be reshaped from *(29 × 200) × (29 × 200)* to the "9800 level". For socio-economic variables where not all 29 countries were represented, zeros were inserted in respective sections (having the country-order alphabetical). Fortunately, all countries with reconciled final demand are also covered in EXIOBASE. Hence, two possibilities exist for reshaping the final demand structure: either to stick to the EXIOBASE country-resolution on both dimensions, i.e. having a *9800 × (49 × p)* matrix, or going for an EXIOBASE-by-Eurostat cut-off matrix, i.e. having a reduced *9800 × (29 × p)* matrix. Both variations are depicted in Figure S1. Due to the better overview along its column-dimension, particularly when further split, we decided to go for the cut-off matrix.

It is important to note that the thus disaggregated household final demand matrix does not yet account for trade, i.e. it only represents demand as if it were all sourced domestically. Trade is included through the multiplication of the present final demand matrix by a trade matrix $\boldsymbol{T}$ for the respective year of size *9800 × 9800* (equation 10); this conversion is conducted irrespective of the column dimension of the final demand, i.e. also other aggregation or disaggregation forms are possible, and even the inclusion of other final demand categories k such as governmental final demand. In the present study, however, these steps were performed later.

$$\boldsymbol{Y}_{i}^{trade} = \boldsymbol{T} * \boldsymbol{Y}_{i}^{balanced,bp,EXIO} \tag{10}$$

The resulting basic final demand matrix $\boldsymbol{Y}_{i}^{trade}$ is of size *9800 × (29 × p)*. The applied trade matrix $\boldsymbol{T}$ is a block matrix of diagonal trade shares between all regions in the model. The one for the year 2010 was provided by Alexandre Tisserant (2018), while the trade matrix for 2005 was derived using a Matlab script provided by the same colleague. The basic concept of it is to calculate the share of each entry in the final demand matrix by the row-sum of it.

Other disaggregation forms of $\boldsymbol{Y}_{i}^{trade}$ were achieved by summing respective columns, e.g. getting the final demand per country (*9800 × 29*), per parameter (*9800 × p*), or across all considered European countries (*9800 × 1*). Including other final demand categories resulted in a final demand matrix of size *9800 × (29 × (p+k))* in its basic form. Further disaggregations were possible from either form by diagonalizing country-sections, e.g. resulting (after potential further modifications) in matrices of the sizes *9800 × (200 × parameter)* or *9800 × (49 × 29 ×*

parameters) etc. Sector groupings were performed via a bridge matrix taken from Ivanova et al. (2017).

Exiobase-by-Exiobase full res.	Exio-country 1, p parameters	Exio-country 2, p parameters	Exio-country 3, p parameters	Exio-country 4, p parameters	Exio-country 5, p parameters	Exio-country 6, p parameters	Exio-country 7, p parameters	Exio-country 8, p parameters	Exio-country 9, p parameters	.	.	.	Exio-country 49, p parameters
Exio-country 1, 200 sectors													
Exio-country 2, 200 sectors													
Exio-country 3, 200 sectors													
Exio-country 4, 200 sectors													
Exio-country 5, 200 sectors													
Exio-country 6, 200 sectors													
Exio-country 7, 200 sectors													
Exio-country 8, 200 sectors													
Exio-country 9, 200 sectors													
.													
.													
.													
Exio-country 49, 200 sectors													

Exiobase-by-Eurostat cut-off	Euro-country 1, p parameters	Euro-country 2, p parameters	Euro-country 3, p parameters	Euro-country 4, p parameters	Euro-country 5, p parameters	Euro-country 6, p parameters	.	.	.	Euro-country 29, p parameters
Exio-country 1, 200 sectors										
Exio-country 2, 200 sectors										
Exio-country 3, 200 sectors										
Exio-country 4, 200 sectors										
Exio-country 5, 200 sectors										
Exio-country 6, 200 sectors										
Exio-country 7, 200 sectors										
Exio-country 8, 200 sectors										
Exio-country 9, 200 sectors										
.										
.										
.										
Exio-country 49, 200 sectors										

Figure S1: Schematic variations of household final demand representations (without trade). Left: EXIOBASE-by-EXIOBASE country full resolution; right: EXIOBASE-by-Eurostat cut-off matrix. Blue fields indicate existing final demand, white fields contain zeros.

SI6. Introduction to EE-IO

Inspired by the general equilibrium theory by Walras and Jaffé (2003), Leontief (1936, 1970) formulated his famous, and by now standard, input-output calculus, also referred to as demand-pull model. Despite the existence of another output model, the supply-driven Ghosh model (Ghosh, 1958), the demand-driven Leontief model is usually preferred for input-output calculations, as can be seen in the literature overview in section SI2, and is briefly outlined in the following (based on: Miller & Blair, 2009; Kitzes, 2013).

Fundamentals of input-output analysis

For a given year *t*, inter-industry requirements of a single-region are expressed through the $n \times n$ matrix $\boldsymbol{Z}$, with *n* being the number of sectors in that country. The total output of this country is denoted by $\boldsymbol{x}$ of the size $n \times 1$, which when diagonalized, inverted, and multiplied by $\boldsymbol{Z}$ yields $\boldsymbol{A}$, the $n \times n$ direct requirements matrix, also called technical coefficients matrix:

$$\boldsymbol{A} = \boldsymbol{Z}\boldsymbol{\hat{x}}^{-1} \tag{11}$$

This can then be inserted into the standard IO production balance, where $\mathbf{y}$ represents the final demand vector of size $n \times 1$, so that the sum of final demand and inter-industry demand equal the total output, i.e. supply and demand are balanced:

$$\boldsymbol{Zi} + \boldsymbol{Yi} = \boldsymbol{A\hat{x}i} + \boldsymbol{y} = \boldsymbol{x} \tag{12}$$

The insertion of equation (11) into equation (12) can then be rewritten as follows, with $\boldsymbol{I}$ being the so-called identity matrix of the same size as $\boldsymbol{A}$ and having ones on the main diagonal and zeros on the off-diagonal, and $\boldsymbol{L}$ being the $n \times n$ Leontief inverse:

$$\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1} \tag{13}$$

Each column of the Leontief inverse shows what is required per sector for meeting the final demand in the respective country. Based on equations (11) to (13), it follows that:

$$\boldsymbol{x} = \boldsymbol{Ly} \tag{14}$$

While the vector and matrix dimensions as depicted above are true for the case of a single-region/national assessment, they change when extending the analysis to a multi-regional input-output model with *m* countries. More specifically, $\boldsymbol{x}$ becomes the $mn \times m$ matrix $\boldsymbol{X}$, $\boldsymbol{A}$ extends its size to $mn \times mn$ (consequently the same goes for $\boldsymbol{L}$), and $\boldsymbol{y}$ turns from a vector to a $mn \times m$ matrix $\boldsymbol{Y}$. In addition, $\boldsymbol{Y}$ may also be further disaggregated into various final demand categories *k*, getting shaped as a $mn \times mk$ matrix.

The environmental dimension comes into play when multiplying the total output $\boldsymbol{X}$ by the stressor intensities included in the $s \times mn$ stressor intensity matrix $\mathbf{S}$, with *s* being the number of emissions and resource uses that are to be accounted for. This multiplication yields the environmental pressure matrix $\boldsymbol{D}$ of size $s \times mk$, showing all emissions and resource uses that are associated with the final demand in the categories k in the selected countries m:

$$\boldsymbol{D} = \boldsymbol{S}\boldsymbol{X} = \boldsymbol{S}(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{Y} \tag{15}$$

When analysing only single environmental pressures, the matrix $\boldsymbol{D}$ turns into the $1 \times mk$ vector $\boldsymbol{d}$. For single-region assessments, the dimension m is excluded from $\boldsymbol{d}$ or $\boldsymbol{D}$, respectively. For country-specific assessments in a multi-regional model, on the other hand, only selected column-sections of the above matrices are of interest.

To complete this introduction into the basics of environmentally-extended input-output analysis, it must be added that the stressor intensity matrix $\boldsymbol{S}$ is derived by dividing the environmental satellite account $\boldsymbol{F}$ of size $s \times mn$, which contains the total emissions and resource uses per sector and country, by the inverted and diagonalized total output:

$$\boldsymbol{S} = \boldsymbol{F}\widehat{\boldsymbol{X}}^{-1} \tag{16}$$

For more details on the basics of input-output analysis and the more specific environmentally extended input-output analysis, the reader is referred to Leontief (1936, 1970), Miller and Blair (2009), and Kitzes (2013).

SI7. The analytical MRIO model

In the present study, four types of footprints were calculated for year t: one purely accounting for environmental pressures, one characterising these pressures onto the midpoint level, and two on the endpoint level, i.e. quantifying resulting biodiversity impacts. While the EXIOBASE v3.4 MRIO data, including its environmental satellite account, was provided by Alexandre Tisserant (2018; can also be downloaded for free from http://www.exiobase.eu/) from the Industrial Ecology programme at NTNU, biodiversity impact assessment data from LC-Impact (Verones et al., 2018) and ReCiPe (Huijbregts et al., 2016) were retrieved from the respective websites; for more details on the treatment of the latter, see section SI10.

As indicated in equation 5 for the general EE-MRIO case, a pressure footprint is calculated by multiplying stressors by the Leontief inverse and the transformed final demand. This same procedure was carried out in the present study for an aggregated selection of stressors $\boldsymbol{S}^{selected}$ of dimension $d \times mn$ and the $mn \times y$ sized final demand $\boldsymbol{Y}_i^{trade}$, disaggregated according to socio-economic variable i, given in basic prices, and accounting for trade. This results in a pressure footprint matrix $\boldsymbol{D}_i$ of size $d \times y$, with y denoting the distinct configuration of the final demand, i.e. in aggregated or disaggregated form, and d denoting the number of selected stressors:

$$\boldsymbol{D}_i = \boldsymbol{S}^{selected}\boldsymbol{L}\boldsymbol{Y}_i^{trade} \tag{17}$$

In comparison, a midpoint environmental multiplier is required for the calculation of the characterised pressure footprint. This $f \times mn$ sized midpoint multiplier $\boldsymbol{n}$ is derived through the multiplication of a set of selected EXIOBASE midpoint characterisation factors, grouped in the $f \times s$ matrix $\boldsymbol{C}$, and the full stressor matrix $\boldsymbol{S}$ ($s \times mn$):

$$\boldsymbol{n} = \boldsymbol{C} * \boldsymbol{S} \tag{18}$$

Multiplying this midpoint environmental multiplier by the Leontief inverse and the final demand results in a characterised pressure footprint $\boldsymbol{P_i}$ of size $f \times y$:

$$\boldsymbol{P_i} = \boldsymbol{nLY_i^{trade}} \tag{19}$$

Both impact footprints require an environmental multiplier, too. Now, however, on the endpoint level. This is achieved through the selection of respective characterisation factors according to either ReCiPe or LC-Impact methodologies, and the subsequent multiplication of them by the stressor matrix. A few differences prevail, however, as outlined in the following.

ReCiPe mid- to endpoint conversion factors in vector $\boldsymbol{R}$ of dimensions $r \times 1$ are element wise multiplied by the product of selected midpoint characterisation factors $\boldsymbol{C}$ and the full stressor matrix $\boldsymbol{S}$, thus resulting in the $r \times mn$ sized ReCiPe multiplier $\boldsymbol{m^{ReCiPe}}$, with r representing the number of ReCiPe impact categories:

$$\boldsymbol{m^{ReCiPe}} = \boldsymbol{R} \circ (\boldsymbol{C} * \boldsymbol{S}) \tag{20}$$

In comparison, a selection of LC-Impact endpoint characterisation factors $\boldsymbol{Q}$ is element wise multiplied by a corresponding aggregated selection of stressors $\boldsymbol{S^{selected}}$ (same as in equation 6), yielding the $u \times mn$ LC-Impact environmental multiplier matrix, with u denoting the number of considered LC-Impact impact categories:

$$\boldsymbol{m^{LC-Impact}} = \boldsymbol{Q} \circ \boldsymbol{S^{selected}} \tag{21}$$

However, the use of $\boldsymbol{Q}$ requires some preparation. Since most of the LC-Impact characterisation factors are spatially explicit (either expressed as cells in raster maps or according to other classifications in shapefiles), they are aggregated according to the EXIOBASE region classification, i.e. 49 countries/regions. It is important to note here that they are not sector wise differentiated. Where applicable, i.e. for land use, water stress, and acidification, the respective characterisation factors are first emission/resource use based weighted in each grid cell g and then aggregated per country/region c, thus yielding country specific, weighted characterisation factors, expressed in a $1 \times m$ row vector $\boldsymbol{j_c}$ per impact category:

$$\boldsymbol{j_c} = \forall_{g \in c} \frac{\sum \boldsymbol{F_g^{selected} j_g^{selected}}}{\sum \boldsymbol{F_g^{selected}}} \tag{22}$$

No such emission/resource use based weighting is possible for the other impact categories due to a lack of geospatial data on total emissions/resource uses; respective characterisation factors are hence only averaged per each country (see section SI10 for details). Moreover, effects from greenhouse gas emissions are not spatially differentiated at all, i.e. only global characterisation factors are available per emission species. For that reason, the same characterisation factor per greenhouse gas emission type is assigned to each country, thus being available as a row vector $\boldsymbol{j_c}$.

All characterisation factor row vectors $\boldsymbol{j_c}$ per impact category are put together in a $u \times m$ sized matrix named $\boldsymbol{Q^{raw}}$. This matrix contains now all characterisation factors for each specified impact category and all regions. As no sectoral differentiation is available, each column of $\boldsymbol{Q^{raw}}$ is then repeated n times so that its size is expanded to $u \times mn$. The resulting matrix is now called $\boldsymbol{Q}$, which is divided by the factor $n = 200$ for reasons of equal weighting - the sum across all sectors per country and impact category equals thus the original characterisation factor per country and impact category. It can then be multiplied against the stressor matrix using a Hadamard product (equation 21).

For either impact footprint type, the environmental multiplier ($\boldsymbol{m^{ReCiPe}}$ or $\boldsymbol{m^{LC\text{-}Impact}}$) is then multiplied by the Leontief inverse and the final demand, resulting in a biodiversity impact footprint $\boldsymbol{B_i}$ of size $v \times y$ (v is the generic number of impact categories, so either u or r):

$$\boldsymbol{B_i = mLY_i^{trade}} \tag{23}$$

A matrix $\boldsymbol{B_{i,u}}$ of size $mn \times y$ depicting the origins and destinations of biodiversity losses due to one impact category v can be obtained through the diagonalization of the environmental multiplier when being multiplied by the Leontief inverse and the final demand:

$$\boldsymbol{B_{i,v} = \widehat{m_v}LY_i^{trade}} \tag{24}$$

Lists of applied stressors/midpoint CFs per footprint and resulting impact categories are outlined in the following section SI8.

Mind that the notations used in this schematic differ from the ones applied in the respective Matlab script; see the documentation in the script for clarification. In addition, the code also includes a section which allows a production layer decomposition, following the procedure in Wieland et al. (2018). Details on and results of that are, however, not shown here, because they would require a separate analysis which would exceed the scope of the present study.

SI8. Stressor aggregates and characterisation factor selections

The calculation of biodiversity footprints required the preparation of stressor and characterisation matrices. Due to data availability, not all impact categories could be covered by both types of impact footprints. LC-Impact footprints account for land occupation, blue water consumption, global warming, photochemical ozone formation, freshwater eutrophication, and terrestrial acidification. In comparison, ReCiPe footprints account for land occupation and relaxation, global warming, blue water consumption, terrestrial acidification, and toxicity. While both impact assessment methodologies also provide characterisation factors for additional impact categories, only the above listed could be matched with the MRIO data.

The limiting factor for the selection of LC-Impact characterisation factors was the availability of the latter (and global emission/resource accounts for weighting). The above described impact categories covered by LC-Impact footprints would be further distinguished into different emission or resource types, for instance, annual crops or methane emissions so that a more detailed allocation of species losses according to pressures was possible. Based on the earlier described analytical MRIO model (SI7), corresponding stressors had to be selected that match the impact categories (Table S8). For different time horizons (core vs extended) and effect factor choices (average vs marginal) as well as ecosystem types (terrestrial vs aquatic), the same stressors were applied, e.g. the sum of stressor matrix rows 427 and 436 for both core and extended footprints in both terrestrial and aquatic ecosystems. Thus, it was assumed that the same pressure can affect biodiversity in different ecosystems over different time horizons. Although in Table S8 also freshwater eutrophication due to Phosphorous emissions to soil is listed, it was later realised that the respective stressor rows are unpopulated; the same goes for urban land use and extensive forestry. The corresponding Excel spreadsheets, however, also list these categories, although the resulting impact is obviously zero.

In contrast, no stressor rows, but EXIOBASE midpoint characterisation matrix rows had to be selected for ReCiPe footprints (Table S9). These factors characterise different stressors into such stressor groups that affect the respective impact category, e.g. carbon dioxide equivalents causing global warming and thus affecting terrestrial and freshwater ecosystems. It was initially tried to account also for freshwater eutrophication, however, it was only after the coding and preparation of the Excel spreadsheets realised that the respective C-matrix row is not populated; thus, no results for freshwater eutrophication could be obtained. Similarly, photochemical ozone formation was tried to be quantified in ReCiPe footprints, but no matching C-matrix rows could be found – this was, however, realised before the preparation of code and files so that it is neither listed here nor in the corresponding spreadsheets.

For an overview of ReCiPe and LC-Impact characterisation factors and how the latter were derived, see SI9.

Table S8: Selected EXIOBASE stressor matrix rows for LC-Impact footprint calculation.

Impact categories	EXIOBASE S rows
Land occupation - annual crops	447 - 457, 459
Land occupation -permanent crops	458
Land occupation - intensive forestry	460
Land occupation - extensive forestry	469
Land occupation - urban	468
Land occupation - pasture	465 - 467
Blue water consumption - surface water (core)	1158 - 1260
Blue water consumption - ground water (extended – core)	1158 - 1260
Global warming - Carbon dioxide (CO2)	24, 93, 94, 428, 438, 439
Global warming - Methane (CH4) - organic	427, 436
Global warming - Methane (CH4) - fossil	25, 68 - 75
Global warming - Nitrous oxide (N2O)	26, 430
Global warming - Sulphur hexafluoride (SF6)	424
Global warming - Non-methane volatile organic compounds (NMVOC)	38, 142 - 188
Photochemical ozone formation - NMVOC	38, 142 - 188
Photochemical ozone formation - Nitrogen oxide (NOx)	28, 189 - 210, 432, 443
Freshwater eutrophication - Phosphorous (P) to soil	434, 444
Freshwater eutrophication - P to water	433
Terrestrial acidification - Ammonia (NH3)	29, 141, 431, 442
Terrestrial acidification - Nitrogen oxide (NOx)	28, 189 - 210, 432, 443
Terrestrial acidification - Sulphur oxide (SOx)	27, 343 - 361, 446

Table S9: Selected EXIOBASE characterisation matrix rows for ReCiPe footprint calculation.

Impact categories	EXIOBASE C rows
Land use - occupation + relaxation	124
Global Warming - Terrestrial ecosystems	9
Global Warming - Freshwater ecosystems	9
Water consumption - terrestrial ecosystems	119
Water consumption -aquatic ecosystems	119
Eutrophication - Freshwater ecosystems	207
Acidification - Terrestrial ecosystems	181
Toxicity - Terrestrial ecosystems	169
Toxicity - Freshwater ecosystems	165, 167
Toxicity - Marine ecosystems	166, 168

SI9. Derivation of characterisation factors

For the assessment of biodiversity loss using consumption-based accounting, characterisation factors (CFs) are required that link environmental pressures with impacts, i.e. emissions and resource uses with their effect on biodiversity. The life cycle impact assessment (LCIA) methodologies LC-Impact and ReCiPe provide metrics for doing so: LC-Impact uses the potentially disappeared fraction of species (PDF), whereas ReCiPe applies direct species loss. Differences between the metrics and resulting implications for the interpretation of biodiversity assessments can be found in the respective reports (Huijbregts et al., 2017; Verones et al., 2018). While the data handling of ReCiPe characterisation factors was fairly simple, LC-Impact characterisation factors required more attention.

ReCiPe's mid- to endpoint conversion factors were downloaded as an Excel spreadsheet from the respective website. It was acknowledged that the ReCiPe authors provided an updated version of the factors in 2017, however, the exact values were not downloadable; hence, the factors of the original version from 2016 were used. Due to time constraints, not country-specific, but only weighted, globally-averaged characterisation factors were applied. The factors account for the following impact categories in terrestrial (t), freshwater (f), and marine (m) ecosystems (Table S10): climate change (t, f), photochemical ozone formation (t), acidification (t), toxicity (t, f, m), water use (t, f), land use (t), and eutrophication (f). ReCiPe provides all these factors for three value choices representing different cultural perspectives: individualist, hierarchist, and egalitarian. For the present study, characterisation factors for the hierarchist perspective were chosen as these are "based on scientific consensus with regard to the time frame [of 100 years] and plausibility of impact mechanisms" (Huijbregts et al., 2017). ReCiPe's metric in the environmental domain is the local species loss integrated over time per environmental pressure.

In comparison to this local focus of ReCiPe, LC-Impact accounts for the global loss of species via a normalisation through vulnerability scores. Spatially-explicit characterisation factors for this LCIA methodology were retrieved through the LC-Impact website in the form of raster and shapefiles as well as Excel spreadsheets. Moreover, also LC-Impact offers value choices, i.e. following the marginal (effect of an incremental increase in the environmental pressure) or average approach ("average effect change per unit of change") for two different time horizons (core, i.e. 100 years, and extended, i.e. 100 years +). In any case, most up-to-date data was used. The data handling differed per impact category and required the use of ArcGIS (ESRI, 2017). The respective layers were constructed using the equal-area Mollweide projection; input data was re-projected if necessary. See Tables S11 – S14 for country-specific factors.

- Preparation: Before the actual CF derivation, global country boarders had to be redefined according to the EXIOBASE world model, i.e. 44 countries and 5 RoW regions. This was achieved by using a map with global country boarders (retrieved from https://www.naturalearthdata.com) and selecting the respective countries belonging to each EXIOBASE region (i.e. having one layer per EXIOBASE region showing the individual country boarders), dissolving them (i.e. having one layer per EXIOBASE region with dissolved country boarders), after which all dissolved EXIOBASE regions could be merged into one map (i.e. having a layer that contains all dissolved EXIOBASE regions).

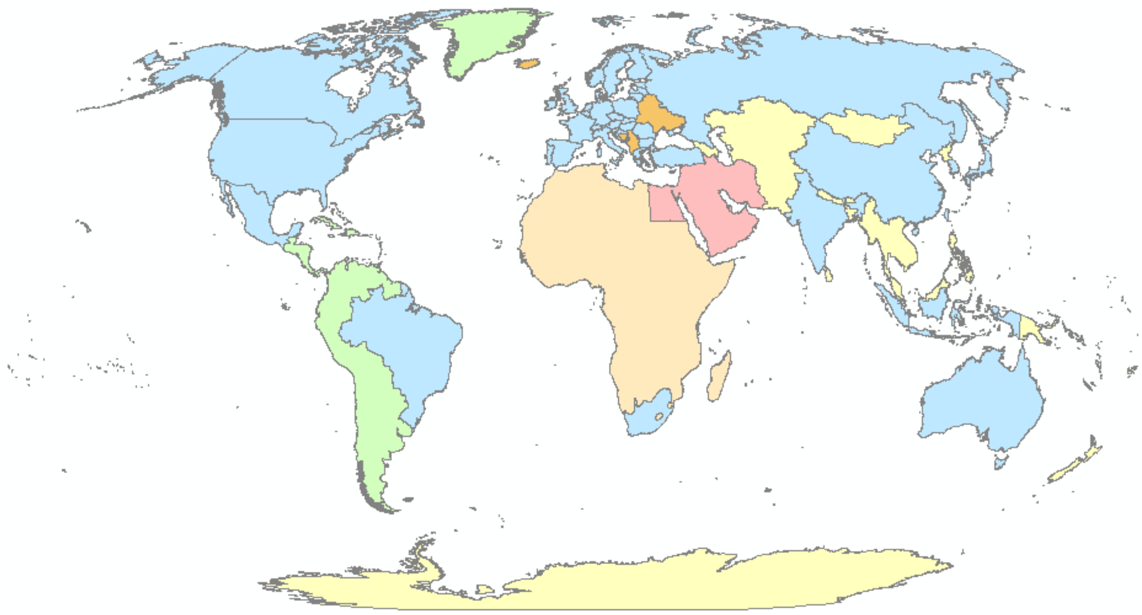

Figure S2: Dissolved EXIOBASE regions. Blue: Core regions including country boarders; light-shaded orange: RoW Africa; green: RoW America; yellow: RoW Asia-Pacific; dark-shaded orange: RoW Europe; red: RoW Middle-East. See Table S2 in section SI3 for the region names.

- Land use: The layer containing EXIOBASE regions was then intersected with a shape-file of terrestrial ecosystems (Olson et al., 2001), which yielded the areas of terrestrial ecosystems per EXIOBASE region. In addition, the total areas per EXIOBASE region were calculated through their polygon geometry. Both lists of land areas were then exported as .txt files and imported into a formatted Excel spreadsheet provided by Verones (2018). In this spreadsheet, land shares of the ecosystem area per respective EXIOBASE region were calculated, which were then multiplied by the CFs per respective terrestrial ecoregion. This procedure yielded area-weighted CFs per terrestrial ecoregion which were then summed, thus resulting in CFs per EXIOBASE region. These area-weighted CFs [PDF/m^2] for land occupation and land transformation were calculated for six different types of land use (annual and permanent crops, pasture, urban, extensive and intensive forestry), each for two different time horizons (core and extended) as well as two different value choices (marginal and average), and are available as median values as well as such accounting for standard deviation (upper and lower 95%; for the impact calculation, only median values were applied).

- Water stress: Marginal CFs (core, i.e. surface water, and extended, i.e. surface and ground water; [PDF/m^3]) and total water consumption values per year were available as rasterised .tiff files. As their cell sizes were different (0.5° x 0.5° vs. 0.05° x 0.05°), the CF raster sets were resampled using the bilinear technique to match the cell size of the water consumption raster. Both CF raster files were then multiplied by the total water consumption using the “times” command”. In a next step, the command “zonal statistics as table” (sum) was applied on the resulting raster sets and on the water consumption raster using the layer with EXIOBASE regions as reference, the resulting values of which were exported into a spreadsheet. The final step was to divide the PDF values per EXIOBASE region by the respective total water consumption to derive spatially-explicit CFs [PDF/m^3] according to the EXIOBASE region classification.

- Terrestrial acidification: Same procedure as for water stress. The cell sizes of the CF raster sets were different, however (2.5° x 2.5°). Marginal CFs [PDF/kg] were calculated for SO_x, NO_x, and NH_3. It must be noted that the calculation of CFs for SO_x was based on a SO_2 emissions raster and an original SO_x CF raster.

- Photochemical ozone formation: Average CFs [PDF/kg] for NO_x and NMVOC were downloaded as shapefiles and intersected with the EXIOBASE regions. Due to incongruencies between both layer sets, an area-based weighting of the CFs was required using the dissolve command. An emission-based weighting was not possible due to missing data on respective total emissions. It must be noted that due to this lack of emission-based weighting, the resulting biodiversity footprints for this category may be slightly skewed.

- Freshwater eutrophication: Similar procedure as for photochemical ozone formation. Average CFs [PDF/kg] were available as shapefiles for Phosphorus emissions to soil and water, and for eutrophication due to erosion. No emission-based weighting was possible. It must be noted that due to this lack of emission-based weighting, the resulting biodiversity footprints for this category may be slightly skewed.

- Greenhouse gas emissions: Both core and extended CFs [PDF/kg] for terrestrial and freshwater ecosystems were downloaded in an Excel file. While CFs for CO_2, CH_4, fossil CH_4, N_2O, and SF_6 were ready to use, a CF for NMVOC had to be calculated by averaging the CFs of respective single emission species. Other GHGs were not accounted for because of the presumably little effect.

Where applied, raster files containing emissions/resource uses as well as the above mentioned Excel spreadsheets for calculating land eco-shares were provided by Verones (2018). Otherwise, the required data was downloaded from the LC-Impact (http://lc-impact.eu/) and ReCiPe webpages (https://www.rivm.nl/en/Topics/L/Life_Cycle_Assessment_LCA/ReCiPe). When viewing the shapefiles in the digital SI, links to the geodatabase may have to be re-established.

Table S10: Selected global ReCiPe characterisation factors (Huijbregts et al., 2016)

Impact category	Unit	Individualistic	Hierarchic	Egalitarian
Terrestrial ecosystems				
Global Warming	Species.year/kg CO2 eq.	5,32E-10	2,80E-09	2,50E-08
Photochemical ozone formation	Species.year/kg NOx eq.	1,29E-07	1,29E-07	1,29E-07
Acidification	Species.year/kg SO2 eq.	2,12E-07	2,12E-07	2,12E-07
Toxicity	Species.year/kg 1,4-DBC emitted to industrial soil eq.	5,39E-08	5,39E-08	5,39E-08
Water consumption	Species.year/m3 consumed	0,00E+00	1,35E-08	1,35E-08
Land use - occupation	Species.year/annual crop eq.	8,88E-09	8,88E-09	8,88E-09
Freshwater ecosystems				
Global Warming	Species.year/kg CO2 eq.	1,45E-14	7,65E-14	6,82E-13
Eutrophication	Species.year/kg P to freshwater eq.	6,10E-07	6,10E-07	6,10E-07
Toxicity	Species.year/kg 1,4-DBC emitted to freshwater eq.	6,95E-10	6,95E-10	6,95E-10
Water consumption	Species.year/m3 consumed	6,04E-13	6,04E-13	6,04E-13
Marine ecosystems				
Toxicity	Species.year/kg 1,4-DBC emitted to sea water eq.	1,05E-10	1,05E-10	1,05E-10

Table S11: Selected spatially explicit LC-Impact characterisation factors, part I

Pressure	Detailed	Unit	Pressure code		AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HR	HU
Land occupation average	Annual crops	[PDF-eq/m2]	L_occ_avg_AC		7,28E-14	2,07E-14	4,41E-14	3,48E-13	2,12E-14	2,02E-14	1,80E-14	1,07E-14	2,48E-13	1,35E-15	8,03E-14	2,46E-13	8,40E-14	2,20E-14
Land occupation average	Permanent crops	[PDF-eq/m2]	L_occ_avg_PC		5,02E-14	1,27E-14	2,60E-14	1,96E-13	1,30E-14	1,24E-14	1,13E-14	5,94E-15	1,56E-13	3,58E-15	5,19E-14	1,42E-13	5,19E-14	1,36E-14
Land occupation average	Pasture	[PDF-eq/m2]	L_occ_avg_Pa		3,81E-14	6,87E-15	1,19E-14	1,02E-13	7,16E-15	6,93E-15	5,55E-15	2,53E-15	6,54E-14	1,59E-15	3,00E-14	7,32E-14	2,43E-14	6,74E-15
Land occupation average	Urban	[PDF-eq/m2]	L_occ_avg_Urb		7,97E-14	1,96E-14	4,16E-14	3,19E-13	1,98E-14	1,91E-14	1,64E-14	1,02E-14	1,94E-13	6,80E-15	8,12E-14	1,94E-13	7,10E-14	2,09E-14
Land occupation average	Extensive forestry	[PDF-eq/m2]	L_occ_avg_EF		1,41E-14	2,13E-15	5,18E-15	6,10E-14	2,41E-15	2,21E-15	1,59E-15	9,26E-16	3,14E-14	1,02E-15	1,44E-14	2,82E-14	1,14E-14	2,46E-15
Land occupation average	Intensive forestry	[PDF-eq/m2]	L_occ_avg_IF		2,04E-14	3,80E-15	5,52E-15	8,85E-14	4,08E-15	3,69E-15	3,28E-15	9,88E-16	6,21E-14	1,07E-15	3,33E-14	6,16E-14	2,24E-14	4,26E-15
Land occupation marginal	Annual crops	[PDF-eq/m2]	L_occ_marg_AC		2,74E-13	5,09E-14	1,41E-13	9,40E-13	5,09E-14	5,04E-14	4,40E-14	3,94E-14	6,59E-13	8,26E-15	2,11E-13	6,32E-13	2,19E-13	5,09E-14
Land occupation marginal	Permanent crops	[PDF-eq/m2]	L_occ_marg_PC		1,96E-13	3,56E-14	9,33E-14	6,18E-13	3,57E-14	3,53E-14	3,07E-14	2,54E-14	4,18E-13	1,76E-14	1,50E-13	3,86E-13	1,42E-13	3,52E-14
Land occupation marginal	Pasture	[PDF-eq/m2]	L_occ_marg_Pa		1,40E-13	2,41E-14	6,36E-14	3,69E-13	2,36E-14	2,36E-14	1,87E-14	1,83E-14	2,05E-13	1,16E-14	9,60E-14	2,14E-13	7,82E-14	2,20E-14
Land occupation marginal	Urban	[PDF-eq/m2]	L_occ_marg_Urb		2,66E-13	5,46E-14	1,34E-13	8,98E-13	5,28E-14	5,27E-14	4,43E-14	3,62E-14	5,27E-13	2,42E-14	2,12E-13	5,15E-13	1,93E-13	5,29E-14
Land occupation marginal	Extensive forestry	[PDF-eq/m2]	L_occ_marg_EF		4,59E-14	8,93E-15	2,96E-14	1,52E-13	9,33E-15	9,06E-15	6,53E-15	8,01E-15	7,20E-14	6,37E-15	4,18E-14	6,93E-14	2,93E-14	9,89E-15
Land occupation marginal	Intensive forestry	[PDF-eq/m2]	L_occ_marg_IF		1,02E-13	1,24E-14	2,81E-14	3,37E-13	1,30E-14	1,26E-14	1,03E-14	7,95E-15	2,04E-13	7,78E-15	1,01E-13	1,98E-13	6,96E-14	1,27E-14
Water consumption	Core	[PDF/m3]	W_core		1,47E-14	3,76E-16	5,68E-15	8,19E-14	5,63E-15	4,03E-15	6,11E-16	2,65E-16	1,23E-14	4,55E-16	6,21E-16	4,81E-15	1,05E-14	1,29E-14
Water consumption	Extended	[PDF/m3]	W_ext		3,17E-14	6,66E-16	9,92E-15	8,17E-14	7,77E-15	5,80E-15	6,12E-16	3,37E-16	1,49E-14	1,22E-15	6,95E-16	4,83E-15	1,64E-14	2,04E-14
Water consumption	Groundwater	[PDF/m3]	W_ground		1,70E-14	2,90E-16	4,24E-15	-2,66E-16	2,13E-15	1,76E-15	1,16E-18	7,16E-17	2,68E-15	7,61E-16	7,35E-17	1,58E-17	5,94E-15	7,50E-15
Carbon dioxide (fossil)	Terrestrial ecosystems core	[PDF*y/kg]	CO2_terr_core		1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15
Carbon dioxide (fossil)	Terrestrial ecosystems extended	[PDF*y/kg]	CO2_terr_ext		1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14
Carbon dioxide (fossil)	Aquatic ecosystems core	[PDF*y/kg]	CO2_aqu_core		5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16
Carbon dioxide (fossil)	Aquatic ecosystems extended	[PDF*y/kg]	CO2_aqu_ext		4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15
Methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4_terr_core		4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14
Methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4_terr_ext		7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14
Methane	Aquatic ecosystems core	[PDF*y/kg]	CH4_aqu_core		1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14
Methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4_aqu_ext		2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14
Fossil methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4fossil_terr_core		5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14
Fossil methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4fossil_terr_ext		7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14
Fossil methane	Aquatic ecosystems core	[PDF*y/kg]	CH4fossil_aqu_core		1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14
Fossil methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4fossil_aqu_ext		2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14
Nitrous oxide	Terrestrial ecosystems core	[PDF*y/kg]	N2O_terr_core		4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13
Nitrous oxide	Terrestrial ecosystems extended	[PDF*y/kg]	N2O_terr_ext		1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12
Nitrous oxide	Aquatic ecosystems core	[PDF*y/kg]	N2O_aqu_core		1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13
Nitrous oxide	Aquatic ecosystems extended	[PDF*y/kg]	N2O_aqu_ext		3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13
Sulphur hexafluoride	Terrestrial ecosystems core	[PDF*y/kg]	SF6_terr_core		4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11
Sulphur hexafluoride	Terrestrial ecosystems extended	[PDF*y/kg]	SF6_terr_ext		5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10
Sulphur hexafluoride	Aquatic ecosystems core	[PDF*y/kg]	SF6_aqu_core		1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11
Sulphur hexafluoride	Aquatic ecosystems extended	[PDF*y/kg]	SF6_aqu_ext		1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10
NMVOC	Terrestrial ecosystems core	[PDF*y/kg]	NMVOC_terr_core		2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12
NMVOC	Terrestrial ecosystems extended	[PDF*y/kg]	NMVOC_terr_ext		1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11
NMVOC	Aquatic ecosystems core	[PDF*y/kg]	NMVOC_aqu_core		9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13
NMVOC	Aquatic ecosystems extended	[PDF*y/kg]	NMVOC_aqu_ext		3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12
POCP	NMVOC	[PDF*y/kg]	POCP_NMVOC		7,74E-16	6,19E-16	5,80E-16	8,11E-16	6,12E-16	6,23E-16	3,96E-16	5,40E-16	9,70E-16	3,53E-16	7,35E-16	7,95E-16	4,86E-16	5,99E-16
POCP	NOx	[PDF*y/kg]	POCP_NOx		1,02E-15	3,15E-16	1,53E-15	2,41E-15	6,22E-16	1,31E-15	3,84E-16	6,20E-16	3,69E-15	2,56E-16	1,61E-15	2,36E-15	2,06E-15	1,08E-15
FW Eutrophication	P2Soil	[PDF*y/kg]	FW_Eutrophication_fertiliser		2,18E-14	5,39E-15	6,23E-14	1,88E-13	1,10E-14	7,99E-15	1,31E-14	1,20E-14	4,07E-14	4,81E-14	6,15E-14	1,21E-13	9,06E-14	2,04E-14
FW Eutrophication	P2Water	[PDF*y/kg]	FW_Eutrophication_PtoWater		2,33E-13	3,52E-14	6,63E-13	1,46E-12	9,81E-14	6,65E-14	7,93E-14	1,45E-13	4,78E-13	2,92E-13	5,02E-13	1,13E-12	9,41E-13	2,22E-13
Terrestrial Acidification	NH3	[PDF*y/kg]	TerrAcid_NH3		3,68E-14	8,93E-16	8,60E-13	2,08E-12	7,46E-15	8,06E-15	3,93E-16	4,00E-16	2,76E-13	1,17E-16	3,09E-14	2,04E-12	1,69E-13	1,63E-15
Terrestrial Acidification	NOx	[PDF*y/kg]	TerrAcid_NOx		1,79E-14	5,11E-16	3,94E-13	1,22E-12	5,89E-15	5,54E-15	2,53E-16	2,09E-16	1,65E-13	4,00E-17	3,01E-14	1,16E-12	6,36E-14	9,22E-16
Terrestrial Acidification	SOx	[PDF*y/kg]	TerrAcid_SOx		3,37E-14	7,20E-16	3,59E-13	6,59E-13	7,05E-15	8,54E-15	3,53E-16	2,27E-16	2,88E-13	4,38E-17	3,04E-14	9,78E-13	8,11E-14	9,57E-16

Table S12: Selected spatially explicit LC-Impact characterisation factors, part II

Pressure	Detailed	Unit	Pressure code	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	GB
Land occupation average	Annual crops	[PDF-eq/m2]	L_occ_avg_AC	9,85E-15	2,07E-13	1,40E-14	1,85E-14	1,09E-14	2,52E-13	2,46E-14	2,57E-14	2,92E-13	4,59E-14	4,33E-15	6,21E-14	5,64E-14	1,16E-14
Land occupation average	Permanent crops	[PDF-eq/m2]	L_occ_avg_PC	5,80E-15	1,28E-13	8,22E-15	1,10E-14	6,09E-15	1,55E-13	1,60E-14	1,66E-14	1,88E-13	3,12E-14	4,25E-15	3,98E-14	3,90E-14	7,22E-15
Land occupation average	Pasture	[PDF-eq/m2]	L_occ_avg_Pa	5,69E-15	6,23E-14	3,85E-15	6,37E-15	2,59E-15	7,66E-14	8,87E-15	8,70E-15	8,63E-14	1,66E-14	1,93E-15	2,33E-14	2,14E-14	5,82E-15
Land occupation average	Urban	[PDF-eq/m2]	L_occ_avg_Urb	1,05E-14	1,69E-13	1,32E-14	1,74E-14	1,05E-14	2,06E-13	2,49E-14	2,38E-14	2,46E-13	4,40E-14	7,66E-15	6,01E-14	5,38E-14	1,23E-14
Land occupation average	Extensive forestry	[PDF-eq/m2]	L_occ_avg_EF	2,00E-16	2,91E-14	1,28E-15	2,08E-15	9,49E-16	3,21E-14	2,80E-15	2,96E-15	3,43E-14	6,71E-15	1,00E-15	1,00E-14	8,64E-15	4,15E-16
Land occupation average	Intensive forestry	[PDF-eq/m2]	L_occ_avg_IF	7,80E-16	5,43E-14	1,86E-15	3,17E-15	1,01E-15	7,17E-14	5,53E-15	5,76E-15	6,41E-14	1,33E-14	1,12E-15	1,65E-14	1,73E-14	1,44E-15
Land occupation marginal	Annual crops	[PDF-eq/m2]	L_occ_marg_AC	3,29E-14	5,37E-13	4,22E-14	4,48E-14	4,04E-14	6,04E-13	6,22E-14	6,23E-14	7,07E-13	1,18E-13	1,77E-14	1,91E-13	1,47E-13	3,73E-14
Land occupation marginal	Permanent crops	[PDF-eq/m2]	L_occ_marg_PC	2,08E-14	3,49E-13	2,79E-14	3,15E-14	2,61E-14	3,91E-13	4,47E-14	4,38E-14	4,60E-13	8,51E-14	1,91E-14	1,30E-13	1,06E-13	2,47E-14
Land occupation marginal	Pasture	[PDF-eq/m2]	L_occ_marg_Pa	2,05E-14	1,89E-13	1,92E-14	2,14E-14	1,87E-14	2,06E-13	3,03E-14	2,80E-14	2,42E-13	5,40E-14	1,32E-14	8,42E-14	6,82E-14	2,11E-14
Land occupation marginal	Urban	[PDF-eq/m2]	L_occ_marg_Urb	3,12E-14	4,53E-13	4,05E-14	4,75E-14	3,71E-14	5,13E-13	6,84E-14	6,26E-14	6,07E-13	1,20E-13	2,67E-14	1,82E-13	1,44E-13	3,67E-14
Land occupation marginal	Extensive forestry	[PDF-eq/m2]	L_occ_marg_EF	3,54E-15	6,50E-14	8,05E-15	8,80E-15	8,21E-15	6,77E-14	1,08E-14	9,86E-15	8,66E-14	1,86E-14	6,51E-15	3,16E-14	2,24E-14	4,24E-15
Land occupation marginal	Intensive forestry	[PDF-eq/m2]	L_occ_marg_IF	5,49E-15	1,80E-13	8,89E-15	1,07E-14	8,15E-15	2,09E-13	1,78E-14	1,75E-14	2,03E-13	4,13E-14	7,74E-15	6,47E-14	5,36E-14	7,46E-15
Water consumption	Core	[PDF/m3]	W_core	6,41E-16	3,34E-15	2,58E-16	5,66E-15	2,49E-16	0,00E+00	8,29E-16	4,24E-16	4,83E-15	5,27E-15	5,09E-16	1,14E-14	1,31E-14	5,88E-16
Water consumption	Extended	[PDF/m3]	W_ext	7,70E-15	3,46E-15	2,63E-16	5,72E-15	4,70E-16	0,00E+00	8,44E-16	5,52E-16	7,00E-15	1,22E-14	5,39E-16	1,83E-14	2,04E-14	2,67E-15
Water consumption	Groundwater	[PDF/m3]	W_ground	7,06E-15	1,22E-16	4,76E-18	6,21E-17	2,21E-16	0,00E+00	1,48E-17	1,28E-16	2,16E-15	6,96E-15	2,97E-17	6,87E-15	7,29E-15	2,09E-15
Carbon dioxide (fossil)	Terrestrial ecosystems core	[PDF*y/kg]	CO2_terr_core	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15
Carbon dioxide (fossil)	Terrestrial ecosystems extended	[PDF*y/kg]	CO2_terr_ext	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14
Carbon dioxide (fossil)	Aquatic ecosystems core	[PDF*y/kg]	CO2_aqu_core	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16
Carbon dioxide (fossil)	Aquatic ecosystems extended	[PDF*y/kg]	CO2_aqu_ext	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15
Methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4_terr_core	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14
Methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4_terr_ext	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14
Methane	Aquatic ecosystems core	[PDF*y/kg]	CH4_aqu_core	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14
Methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4_aqu_ext	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14
Fossil methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4fossil_terr_core	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14
Fossil methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4fossil_terr_ext	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14
Fossil methane	Aquatic ecosystems core	[PDF*y/kg]	CH4fossil_aqu_core	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14
Fossil methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4fossil_aqu_ext	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14
Nitrous oxide	Terrestrial ecosystems core	[PDF*y/kg]	N2O_terr_core	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13
Nitrous oxide	Terrestrial ecosystems extended	[PDF*y/kg]	N2O_terr_ext	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12
Nitrous oxide	Aquatic ecosystems core	[PDF*y/kg]	N2O_aqu_core	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13
Nitrous oxide	Aquatic ecosystems extended	[PDF*y/kg]	N2O_aqu_ext	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13
Sulphur hexafluoride	Terrestrial ecosystems core	[PDF*y/kg]	SF6_terr_core	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11
Sulphur hexafluoride	Terrestrial ecosystems extended	[PDF*y/kg]	SF6_terr_ext	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10
Sulphur hexafluoride	Aquatic ecosystems core	[PDF*y/kg]	SF6_aqu_core	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11
Sulphur hexafluoride	Aquatic ecosystems extended	[PDF*y/kg]	SF6_aqu_ext	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10
NMVOC	Terrestrial ecosystems core	[PDF*y/kg]	NMVOC_terr_core	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12
NMVOC	Terrestrial ecosystems extended	[PDF*y/kg]	NMVOC_terr_ext	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11
NMVOC	Aquatic ecosystems core	[PDF*y/kg]	NMVOC_aqu_core	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13
NMVOC	Aquatic ecosystems extended	[PDF*y/kg]	NMVOC_aqu_ext	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12
POCP	NMVOC	[PDF*y/kg]	POCP_NMVOC	5,87E-16	1,28E-15	5,44E-16	6,19E-16	5,43E-16	1,28E-15	5,88E-16	5,44E-16	9,60E-16	5,84E-16	4,03E-16	7,74E-16	6,12E-16	5,87E-16
POCP	NOx	[PDF*y/kg]	POCP_NOx	3,56E-16	1,91E-15	6,26E-16	3,10E-16	6,23E-16	1,91E-15	3,24E-16	6,25E-16	3,66E-15	1,60E-15	3,91E-16	1,04E-15	6,18E-16	3,57E-16
FW Eutrophication	P2Soil	[PDF*y/kg]	FW_Eutrophication_fertiliser	9,66E-15	3,92E-14	8,40E-15	5,41E-15	1,24E-14	4,21E-14	1,06E-14	5,66E-15	3,18E-14	1,85E-14	4,86E-14	1,39E-13	2,19E-14	7,34E-15
FW Eutrophication	P2Water	[PDF*y/kg]	FW_Eutrophication_PtoWater	1,42E-13	3,56E-13	7,68E-14	3,54E-14	1,50E-13	4,40E-13	9,00E-14	3,73E-14	3,47E-13	2,03E-13	2,84E-13	9,54E-13	2,30E-13	8,55E-14
Terrestrial Acidification	NH3	[PDF*y/kg]	TerrAcid_NH3	2,90E-16	7,56E-12	2,11E-16	4,96E-16	4,73E-16	0,00E+00	6,85E-16	9,80E-16	7,98E-14	1,86E-13	3,28E-16	3,97E-15	1,20E-15	5,74E-16
Terrestrial Acidification	NOx	[PDF*y/kg]	TerrAcid_NOx	1,57E-16	3,12E-12	1,08E-16	3,28E-16	1,93E-16	0,00E+00	4,22E-16	5,17E-16	1,29E-13	5,52E-14	1,56E-16	3,09E-15	6,48E-16	3,26E-16
Terrestrial Acidification	SOx	[PDF*y/kg]	TerrAcid_SOx	2,24E-16	1,81E-12	1,30E-16	4,45E-16	1,76E-16	0,00E+00	5,16E-16	5,55E-16	3,51E-13	2,93E-14	2,98E-16	3,23E-15	7,07E-16	3,52E-16

Table S13: Selected spatially explicit LC-Impact characterisation factors, part III

Pressure	Detailed	Unit	Pressure code	US	JP	CN	CA	KR	BR	IN	MX	RU	AU	CH	TR	TW	NO
Land occupation average	Annual crops	[PDF-eq/m2]	L_occ_avg_AC	3,14E-14	1,35E-13	4,98E-14	4,37E-15	5,08E-14	1,43E-13	1,29E-13	2,81E-13	4,30E-15	6,61E-14	7,11E-14	1,58E-13	9,61E-13	2,46E-15
Land occupation average	Permanent crops	[PDF-eq/m2]	L_occ_avg_PC	2,19E-14	9,07E-14	3,48E-14	4,15E-15	3,54E-14	9,94E-14	9,36E-14	2,04E-13	3,93E-15	4,21E-14	4,89E-14	9,61E-14	6,97E-13	2,46E-15
Land occupation average	Pasture	[PDF-eq/m2]	L_occ_avg_Pa	1,61E-14	3,18E-14	3,03E-14	3,43E-15	1,61E-14	9,50E-14	6,00E-14	1,61E-13	3,16E-15	3,92E-14	3,75E-14	5,37E-14	6,52E-13	1,90E-15
Land occupation average	Urban	[PDF-eq/m2]	L_occ_avg_Urb	3,76E-14	1,47E-13	5,60E-14	6,85E-15	5,38E-14	1,64E-13	1,42E-13	3,31E-13	7,78E-15	6,10E-14	7,78E-14	1,34E-13	1,08E-12	4,48E-15
Land occupation average	Extensive forestry	[PDF-eq/m2]	L_occ_avg_EF	4,16E-15	2,13E-14	5,87E-15	9,32E-16	8,02E-15	3,01E-14	2,51E-14	4,92E-14	8,89E-16	5,54E-15	1,38E-14	1,52E-14	2,38E-13	7,25E-16
Land occupation average	Intensive forestry	[PDF-eq/m2]	L_occ_avg_IF	1,02E-14	4,32E-14	2,28E-14	1,59E-15	1,73E-14	8,94E-14	7,13E-14	1,19E-13	1,50E-15	1,57E-14	1,99E-14	3,51E-14	7,08E-13	9,46E-16
Land occupation marginal	Annual crops	[PDF-eq/m2]	L_occ_marg_AC	9,16E-14	4,67E-13	1,42E-13	1,29E-14	1,38E-13	3,78E-13	3,49E-13	8,64E-13	1,42E-14	2,20E-13	2,69E-13	4,33E-13	2,42E-12	1,01E-14
Land occupation marginal	Permanent crops	[PDF-eq/m2]	L_occ_marg_PC	6,77E-14	3,22E-13	1,05E-13	1,25E-14	1,03E-13	2,83E-13	2,76E-13	6,52E-13	1,45E-14	1,47E-13	1,92E-13	2,81E-13	1,83E-12	1,06E-14
Land occupation marginal	Pasture	[PDF-eq/m2]	L_occ_marg_Pa	4,73E-14	1,95E-13	8,60E-14	1,02E-14	6,33E-14	2,52E-13	1,88E-13	5,16E-13	1,24E-14	1,22E-13	1,38E-13	1,74E-13	1,66E-12	8,52E-15
Land occupation marginal	Urban	[PDF-eq/m2]	L_occ_marg_Urb	1,02E-13	4,51E-13	1,50E-13	1,71E-14	1,47E-13	4,13E-13	3,94E-13	9,54E-13	2,26E-14	1,91E-13	2,61E-13	3,87E-13	2,56E-12	1,46E-14
Land occupation marginal	Extensive forestry	[PDF-eq/m2]	L_occ_marg_EF	1,60E-14	8,30E-14	2,55E-14	3,97E-15	2,62E-14	8,76E-14	7,37E-14	1,68E-13	4,86E-15	2,78E-14	4,50E-14	5,24E-14	5,63E-13	3,65E-15
Land occupation marginal	Intensive forestry	[PDF-eq/m2]	L_occ_marg_IF	3,73E-14	1,43E-13	7,18E-14	6,12E-15	5,28E-14	2,51E-13	2,17E-13	4,22E-13	6,67E-15	6,06E-14	9,95E-14	1,26E-13	1,85E-12	5,34E-15
Water consumption	Core	[PDF/m3]	W_core	1,19E-12	1,49E-14	2,36E-15	2,58E-13	4,52E-14	2,79E-15	1,20E-14	1,22E-14	3,50E-15	2,16E-12	6,91E-15	2,06E-14	2,31E-13	8,31E-16
Water consumption	Extended	[PDF/m3]	W_ext	1,19E-12	6,33E-14	2,39E-15	2,60E-13	5,42E-14	2,88E-15	1,21E-14	1,23E-14	3,50E-15	2,24E-12	7,19E-15	2,10E-14	2,31E-13	8,33E-16
Water consumption	Groundwater	[PDF/m3]	W_ground	1,18E-15	4,84E-14	2,62E-17	1,60E-15	9,06E-15	8,53E-17	3,65E-17	1,07E-16	8,59E-18	8,60E-14	2,87E-16	3,54E-16	3,17E-18	1,50E-18
Carbon dioxide (fossil)	Terrestrial ecosystems core	[PDF*y/kg]	CO2_terr_core	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15
Carbon dioxide (fossil)	Terrestrial ecosystems extended	[PDF*y/kg]	CO2_terr_ext	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14
Carbon dioxide (fossil)	Aquatic ecosystems core	[PDF*y/kg]	CO2_aqu_core	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16
Carbon dioxide (fossil)	Aquatic ecosystems extended	[PDF*y/kg]	CO2_aqu_ext	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15
Methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4_terr_core	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14
Methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4_terr_ext	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14
Methane	Aquatic ecosystems core	[PDF*y/kg]	CH4_aqu_core	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14
Methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4_aqu_ext	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14
Fossil methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4fossil_terr_core	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14
Fossil methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4fossil_terr_ext	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14
Fossil methane	Aquatic ecosystems core	[PDF*y/kg]	CH4fossil_aqu_core	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14
Fossil methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4fossil_aqu_ext	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14
Nitrous oxide	Terrestrial ecosystems core	[PDF*y/kg]	N2O_terr_core	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13
Nitrous oxide	Terrestrial ecosystems extended	[PDF*y/kg]	N2O_terr_ext	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12
Nitrous oxide	Aquatic ecosystems core	[PDF*y/kg]	N2O_aqu_core	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13
Nitrous oxide	Aquatic ecosystems extended	[PDF*y/kg]	N2O_aqu_ext	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13
Sulphur hexafluoride	Terrestrial ecosystems core	[PDF*y/kg]	SF6_terr_core	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11
Sulphur hexafluoride	Terrestrial ecosystems extended	[PDF*y/kg]	SF6_terr_ext	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10
Sulphur hexafluoride	Aquatic ecosystems core	[PDF*y/kg]	SF6_aqu_core	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11
Sulphur hexafluoride	Aquatic ecosystems extended	[PDF*y/kg]	SF6_aqu_ext	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10
NMVOC	Terrestrial ecosystems core	[PDF*y/kg]	NMVOC_terr_core	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12
NMVOC	Terrestrial ecosystems extended	[PDF*y/kg]	NMVOC_terr_ext	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11
NMVOC	Aquatic ecosystems core	[PDF*y/kg]	NMVOC_aqu_core	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13
NMVOC	Aquatic ecosystems extended	[PDF*y/kg]	NMVOC_aqu_ext	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12
POCP	NMVOC	[PDF*y/kg]	POCP_NMVOC	1,58E-15	9,78E-16	2,85E-16	2,61E-16	1,34E-15	5,77E-17	2,10E-16	3,36E-16	2,81E-16	2,36E-17	7,12E-16	7,48E-16	1,01E-14	3,57E-16
POCP	NOx	[PDF*y/kg]	POCP_NOx	8,23E-17	1,06E-15	4,14E-17	5,87E-16	1,85E-15	2,48E-15	5,66E-16	1,61E-14	1,03E-15	1,11E-16	1,90E-15	3,68E-15	-2,00E-14	7,54E-16
FW Eutrophication	P2Soil	[PDF*y/kg]	FW_Eutrophication_fertiliser	4,18E-13	4,35E-14	9,77E-14	1,04E-14	6,70E-14	3,20E-13	3,54E-13	1,01E-12	5,72E-14	5,11E-14	8,94E-15	2,12E-13	2,40E-12	8,18E-14
FW Eutrophication	P2Water	[PDF*y/kg]	FW_Eutrophication_PtoWater	4,33E-12	5,18E-13	1,10E-12	1,21E-13	9,69E-13	3,14E-12	3,95E-12	8,10E-12	4,76E-13	7,68E-13	6,05E-14	2,16E-12	1,47E-11	4,21E-13
Terrestrial Acidification	NH3	[PDF*y/kg]	TerrAcid_NH3	4,32E-13	9,76E-14	2,17E-14	2,68E-15	2,37E-15	9,42E-13	6,08E-14	8,03E-12	2,42E-14	3,94E-13	3,67E-14	1,28E-12	2,89E-12	5,10E-16
Terrestrial Acidification	NOx	[PDF*y/kg]	TerrAcid_NOx	6,91E-14	2,90E-14	1,06E-14	1,47E-15	7,66E-16	1,96E-13	2,80E-14	1,09E-12	2,37E-14	4,30E-13	2,53E-14	6,43E-13	1,19E-12	1,53E-16
Terrestrial Acidification	SOx	[PDF*y/kg]	TerrAcid_SOx	3,25E-14	5,02E-14	3,17E-14	1,46E-15	1,53E-15	2,22E-13	6,94E-14	2,28E-12	3,66E-14	2,55E-13	3,49E-14	4,65E-13	2,21E-12	1,73E-16

Table S14: Selected spatially explicit LC-Impact characterisation factors, part IV

Pressure	Detailed	Unit	Pressure code		ID	ZA	WA	WL	WE	WF	WM
Land occupation average	Annual crops	[PDF-eq/m2]	L_occ_avg_AC		4,42E-13	2,35E-13	4,27E-14	1,56E-13	3,22E-14	6,03E-14	2,70E-14
Land occupation average	Permanent crops	[PDF-eq/m2]	L_occ_avg_PC		3,21E-13	1,44E-13	3,18E-14	1,19E-13	2,03E-14	4,22E-14	1,78E-14
Land occupation average	Pasture	[PDF-eq/m2]	L_occ_avg_Pa		2,55E-13	1,24E-13	2,57E-14	1,06E-13	9,46E-15	4,17E-14	1,68E-14
Land occupation average	Urban	[PDF-eq/m2]	L_occ_avg_Urb		5,20E-13	2,27E-13	4,96E-14	1,91E-13	2,93E-14	7,60E-14	2,92E-14
Land occupation average	Extensive forestry	[PDF-eq/m2]	L_occ_avg_EF		1,19E-13	1,44E-14	9,05E-15	3,03E-14	4,00E-15	8,67E-15	1,48E-15
Land occupation average	Intensive forestry	[PDF-eq/m2]	L_occ_avg_IF		2,94E-13	7,06E-14	2,43E-14	9,38E-14	7,80E-15	2,99E-14	3,54E-15
Land occupation marginal	Annual crops	[PDF-eq/m2]	L_occ_marg_AC		1,31E-12	7,44E-13	1,27E-13	4,40E-13	8,36E-14	1,92E-13	8,04E-14
Land occupation marginal	Permanent crops	[PDF-eq/m2]	L_occ_marg_PC		9,83E-13	4,77E-13	9,76E-14	3,41E-13	5,70E-14	1,37E-13	5,31E-14
Land occupation marginal	Pasture	[PDF-eq/m2]	L_occ_marg_Pa		8,31E-13	3,49E-13	8,24E-14	2,94E-13	3,28E-14	1,23E-13	4,39E-14
Land occupation marginal	Urban	[PDF-eq/m2]	L_occ_marg_Urb		1,43E-12	7,17E-13	1,39E-13	4,95E-13	8,36E-14	2,18E-13	7,66E-14
Land occupation marginal	Extensive forestry	[PDF-eq/m2]	L_occ_marg_EF		3,56E-13	6,21E-14	2,92E-14	9,61E-14	1,26E-14	3,52E-14	8,01E-15
Land occupation marginal	Intensive forestry	[PDF-eq/m2]	L_occ_marg_IF		9,45E-13	2,52E-13	7,90E-14	2,77E-13	2,55E-14	9,61E-14	1,41E-14
Water consumption	Core	[PDF/m3]	W_core		2,61E-14	1,66E-14	2,75E-14	6,49E-14	2,48E-15	1,30E-14	2,08E-14
Water consumption	Extended	[PDF/m3]	W_ext		2,61E-14	1,66E-14	2,77E-14	6,50E-14	3,77E-15	2,48E-14	2,12E-14
Water consumption	Groundwater	[PDF/m3]	W_ground		5,97E-19	-9,06E-19	2,27E-16	1,07E-16	1,29E-15	1,19E-14	4,55E-16
Carbon dioxide (fossil)	Terrestrial ecosystems core	[PDF*y/kg]	CO2_terr_core		1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15	1,76E-15
Carbon dioxide (fossil)	Terrestrial ecosystems extended	[PDF*y/kg]	CO2_terr_ext		1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14	1,57E-14
Carbon dioxide (fossil)	Aquatic ecosystems core	[PDF*y/kg]	CO2_aqu_core		5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16	5,47E-16
Carbon dioxide (fossil)	Aquatic ecosystems extended	[PDF*y/kg]	CO2_aqu_ext		4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15	4,87E-15
Methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4_terr_core		4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14	4,93E-14
Methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4_terr_ext		7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14	7,47E-14
Methane	Aquatic ecosystems core	[PDF*y/kg]	CH4_aqu_core		1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14	1,53E-14
Methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4_aqu_ext		2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14	2,32E-14
Fossil methane	Terrestrial ecosystems core	[PDF*y/kg]	CH4fossil_terr_core		5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14	5,28E-14
Fossil methane	Terrestrial ecosystems extended	[PDF*y/kg]	CH4fossil_terr_ext		7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14	7,67E-14
Fossil methane	Aquatic ecosystems core	[PDF*y/kg]	CH4fossil_aqu_core		1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14	1,64E-14
Fossil methane	Aquatic ecosystems extended	[PDF*y/kg]	CH4fossil_aqu_ext		2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14	2,39E-14
Nitrous oxide	Terrestrial ecosystems core	[PDF*y/kg]	N2O_terr_core		4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13	4,66E-13
Nitrous oxide	Terrestrial ecosystems extended	[PDF*y/kg]	N2O_terr_ext		1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12	1,24E-12
Nitrous oxide	Aquatic ecosystems core	[PDF*y/kg]	N2O_aqu_core		1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13	1,45E-13
Nitrous oxide	Aquatic ecosystems extended	[PDF*y/kg]	N2O_aqu_ext		3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13	3,84E-13
Sulphur hexafluoride	Terrestrial ecosystems core	[PDF*y/kg]	SF6_terr_core		4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11	4,14E-11
Sulphur hexafluoride	Terrestrial ecosystems extended	[PDF*y/kg]	SF6_terr_ext		5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10	5,39E-10
Sulphur hexafluoride	Aquatic ecosystems core	[PDF*y/kg]	SF6_aqu_core		1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11	1,29E-11
Sulphur hexafluoride	Aquatic ecosystems extended	[PDF*y/kg]	SF6_aqu_ext		1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10	1,67E-10
NMVOC	Terrestrial ecosystems core	[PDF*y/kg]	NMVOC_terr_core		2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12	2,92E-12
NMVOC	Terrestrial ecosystems extended	[PDF*y/kg]	NMVOC_terr_ext		1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11	1,03E-11
NMVOC	Aquatic ecosystems core	[PDF*y/kg]	NMVOC_aqu_core		9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13	9,07E-13
NMVOC	Aquatic ecosystems extended	[PDF*y/kg]	NMVOC_aqu_ext		3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12	3,19E-12
POCP	NMVOC	[PDF*y/kg]	POCP_NMVOC		2,54E-17	2,02E-16	4,12E-17	1,01E-16	4,82E-16	1,79E-16	2,20E-16
POCP	NOx	[PDF*y/kg]	POCP_NOx		7,96E-16	3,74E-16	5,04E-16	1,43E-15	1,10E-15	1,14E-15	1,37E-15
FW Eutrophication	P2Soil	[PDF*y/kg]	FW_Eutrophication_fertiliser		2,79E-13	3,48E-13	5,12E-14	2,60E-13	3,25E-14	3,61E-13	3,73E-14
FW Eutrophication	P2Water	[PDF*y/kg]	FW_Eutrophication_PtoWater		2,24E-12	3,77E-12	5,41E-13	2,55E-12	3,53E-13	2,75E-12	2,79E-13
Terrestrial Acidification	NH3	[PDF*y/kg]	TerrAcid_NH3		2,83E-14	8,26E-12	2,50E-12	1,65E-11	1,95E-13	3,16E-13	8,37E-12
Terrestrial Acidification	NOx	[PDF*y/kg]	TerrAcid_NOx		2,87E-14	6,99E-12	1,04E-12	7,25E-13	5,85E-14	4,29E-13	7,15E-12
Terrestrial Acidification	SOx	[PDF*y/kg]	TerrAcid_SOx		2,56E-14	7,54E-12	3,67E-13	1,08E-12	5,96E-14	1,47E-13	5,29E-12

SI10. Footprint results and data analysis

Biodiversity footprints were calculated according to the two impact assessment methodologies LC-Impact and ReCiPe. The main focus of the present study was the disaggregation of the household final demand and the corresponding biodiversity footprints for the years 2005 and 2010 according to the socio-economic variables DEG (degrees of urbanisation), INC (income quintiles), AGE (age of the main income earner), and TYP (types of households). It was found that the general signal across the impact assessment methodologies and over the years remained stable (Figures S3 and S4).

Additional results and those supporting the ones presented in the main section are now shown below as well as in the digital SI. Due to the wealth of results, not all of them can be shown here.

Impact categories may be abbreviated in some tables and/or figures, but the meaning of them should become clear within context, e.g. GW and glob. warm. for global warming or POCP for photochemical ozone creation potential.

For annual comparison of disaggregated footprints, 2010 data was used for missing 2005 footprints. Such a substitution was not always possible (cf. SI4). It was found that differences between pressure and characterised pressure exist; this may have implications for ReCiPe vs LC-Impact in some impact categories like blue water consumption, see digital SI for details. A further in-depth examination of this was, however, out of scope in the present study.

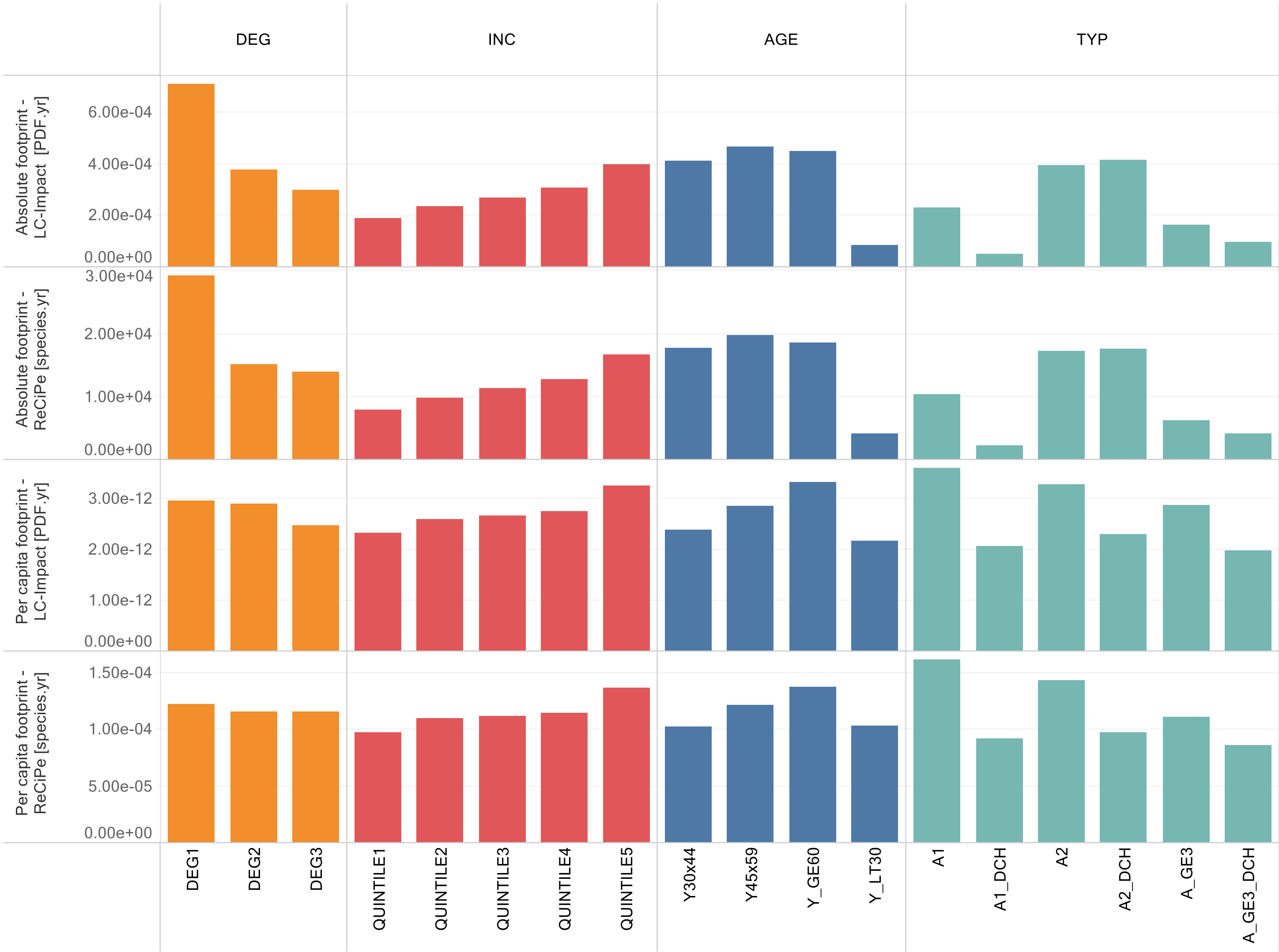

Figure S3: General signal of biodiversity footprints in 2010. The figure shows absolute and per capita footprints per socio-economic variable using both LC-Impact and ReCiPe methodologies. Mind the country exclusions per socio-economic variable shown in Tables S4 – S7.

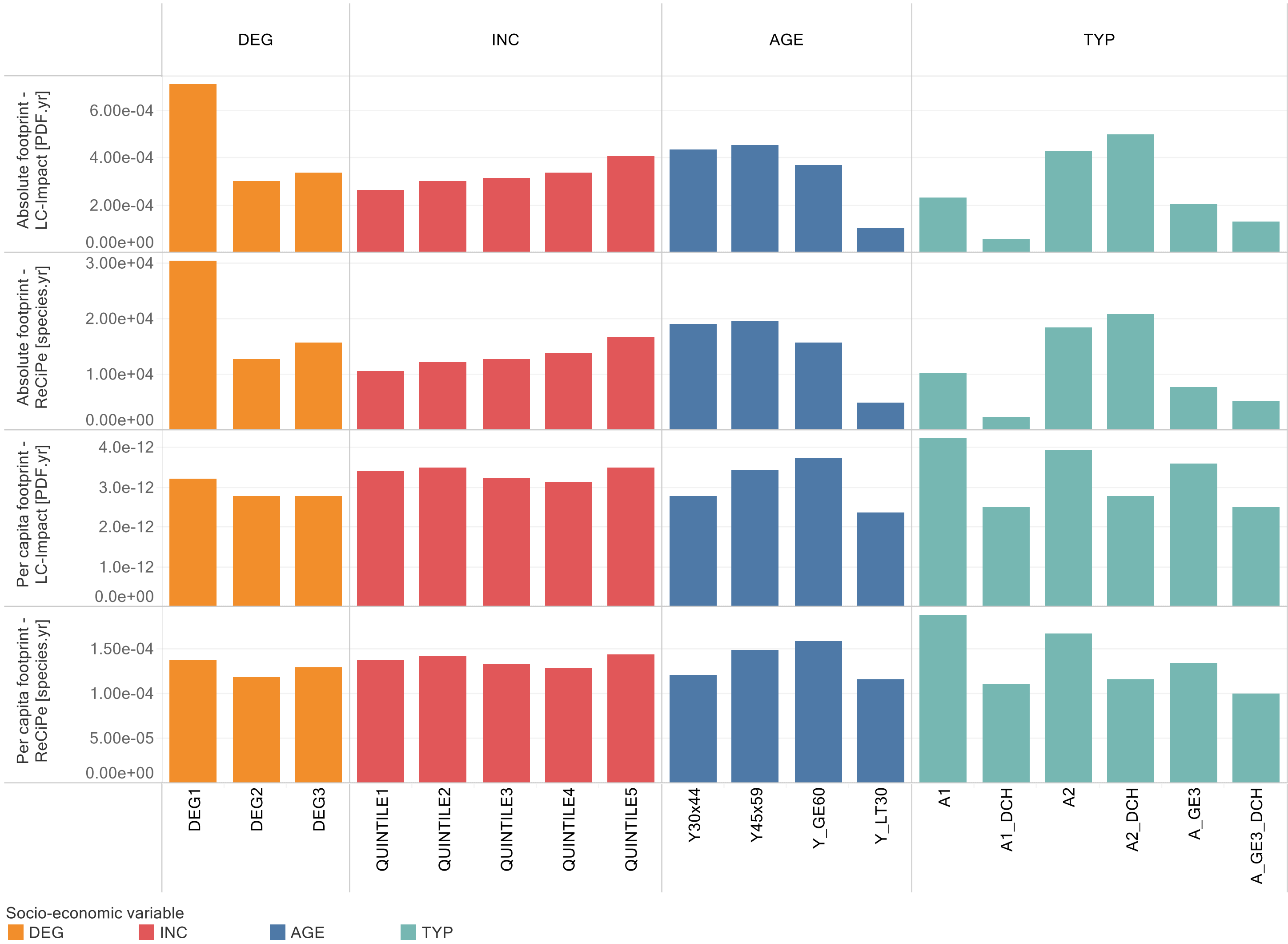

Figure S4: General signal of biodiversity footprints in 2010. The figure shows absolute and per capita footprints per socio-economic variable using both LC-Impact and ReCiPe methodologies. Mind the country exclusions per socio-economic variable shown in Tables S4 – S7.

Table S15: 2010 absolute biodiversity footprints LC-Impact footprints are measured in [PDF.yr] whereas ReCiPe footprints are measured in [species.yr]. The impact categories follow the description in section SI8. Categories like Land or Toxicity cover all the relevant sub-categories. TOTAL sums up all impacts per impact assessment method. AVG denotes the average, SUM is the summed total.

	LC-Impact							ReCiPe					
	Land	Water	Glob. warm.	POCP	Eutroph.	Terr. acid.	TOTAL	Land	Water	Glob. warm.	Toxicity	Terr. acid.	TOTAL
AT	1,71E-05	3,54E-07	2,09E-06	1,03E-09	6,15E-09	1,82E-06	2,14E-05	7,61E+02	1,59E+01	1,64E+02	3,00E+00	9,50E+01	1,04E+03
BE	2,96E-05	1,01E-06	2,87E-06	1,08E-09	1,30E-08	3,61E-06	3,71E-05	1,10E+03	4,22E+01	2,21E+02	4,63E+00	1,58E+02	1,53E+03
BG	5,87E-06	1,04E-07	1,11E-06	7,97E-10	1,33E-09	1,42E-06	8,51E-06	4,46E+02	6,63E+00	1,28E+02	1,44E+00	1,43E+02	7,25E+02
CY	2,51E-06	9,73E-08	3,31E-07	8,74E-10	7,94E-10	1,02E-06	3,97E-06	1,06E+02	4,59E+00	2,94E+01	4,45E+00	2,92E+01	1,74E+02
CZ	9,31E-06	2,48E-07	2,09E-06	7,36E-10	2,89E-09	1,41E-06	1,31E-05	5,39E+02	1,25E+01	2,19E+02	1,76E+00	1,07E+02	8,80E+02
DE	1,49E-04	5,56E-06	1,75E-05	1,04E-08	7,79E-08	1,83E-05	1,91E-04	6,02E+03	1,89E+02	1,62E+03	4,61E+01	9,27E+02	8,80E+03
DK	8,84E-06	2,39E-07	1,50E-06	8,34E-10	3,59E-09	1,43E-06	1,20E-05	5,37E+02	1,22E+01	1,19E+02	9,97E+00	1,08E+02	7,86E+02
EE	1,50E-06	2,86E-08	2,81E-07	1,04E-10	6,81E-10	1,07E-07	1,92E-06	1,40E+02	1,39E+00	3,03E+01	5,26E-01	1,85E+01	1,90E+02
ES	1,98E-04	3,09E-06	7,90E-06	9,20E-09	3,93E-08	8,47E-06	2,18E-04	4,12E+03	1,83E+02	6,13E+02	1,11E+01	3,95E+02	5,32E+03
FI	6,77E-06	2,09E-07	1,75E-06	5,58E-10	3,99E-09	1,06E-06	9,80E-06	1,16E+03	1,06E+01	1,61E+02	3,71E+00	7,63E+01	1,42E+03
FR	1,44E-04	2,51E-06	1,20E-05	7,98E-09	4,50E-08	9,76E-06	1,69E-04	5,43E+03	1,25E+02	9,43E+02	1,62E+01	6,96E+02	7,21E+03
GR	4,62E-05	8,27E-07	3,68E-06	8,61E-09	7,04E-09	9,64E-06	6,03E-05	1,16E+03	5,69E+01	3,34E+02	4,47E+01	3,33E+02	1,93E+03
HR	8,64E-06	8,59E-08	6,09E-07	4,35E-10	2,01E-09	4,22E-07	9,76E-06	4,18E+02	4,18E+00	4,16E+01	9,18E-01	2,73E+01	4,92E+02
HU	6,04E-06	1,51E-07	1,39E-06	5,98E-10	1,67E-09	5,21E-07	8,11E-06	4,52E+02	7,33E+00	1,06E+02	1,02E+00	5,19E+01	6,18E+02
IE	7,38E-06	3,43E-07	1,18E-06	4,13E-10	4,13E-09	9,93E-07	9,90E-06	4,52E+02	1,10E+01	1,04E+02	1,75E+00	6,52E+01	6,34E+02
IT	1,94E-04	3,25E-06	1,35E-05	9,61E-09	5,38E-08	3,61E-05	2,47E-04	5,02E+03	1,75E+02	1,05E+03	2,87E+01	6,49E+02	6,92E+03
LT	3,10E-06	1,36E-07	5,19E-07	2,09E-10	1,06E-09	2,27E-07	3,98E-06	3,95E+02	3,45E+00	4,59E+01	7,31E-01	2,89E+01	4,74E+02
LU	2,64E-06	9,26E-08	2,13E-07	7,76E-11	1,02E-09	3,46E-07	3,29E-06	1,00E+02	4,69E+00	1,49E+01	3,76E-01	1,02E+01	1,31E+02
LV	1,13E-06	4,08E-08	3,24E-07	1,42E-10	5,70E-10	2,32E-07	1,73E-06	1,97E+02	1,46E+00	2,42E+01	4,51E-01	1,87E+01	2,42E+02
MT	6,47E-07	1,74E-08	1,33E-07	5,78E-11	2,02E-10	1,20E-07	9,18E-07	2,36E+01	7,19E-01	7,73E+00	1,74E-01	4,52E+00	3,68E+01
NL	5,31E-05	1,39E-06	4,53E-06	1,45E-09	2,26E-08	6,13E-06	6,52E-05	1,71E+03	5,80E+01	3,55E+02	5,88E+00	2,14E+02	2,34E+03
PL	3,16E-05	8,04E-07	7,05E-06	2,87E-09	8,38E-09	2,24E-06	4,17E-05	2,19E+03	5,73E+01	7,99E+02	5,90E+00	4,38E+02	3,49E+03
PT	4,28E-05	4,73E-07	1,68E-06	2,27E-09	7,48E-09	1,46E-06	4,64E-05	9,08E+02	3,19E+01	1,41E+02	2,38E+00	8,42E+01	1,17E+03
RO	2,60E-05	2,55E-07	2,17E-06	1,48E-09	2,66E-09	1,09E-06	2,95E-05	1,53E+03	1,88E+01	1,85E+02	2,16E+00	1,61E+02	1,89E+03
SE	1,35E-05	4,55E-07	2,08E-06	8,43E-10	7,12E-09	1,91E-06	1,80E-05	1,43E+03	1,96E+01	1,75E+02	5,16E+00	1,15E+02	1,75E+03
SI	4,11E-06	1,06E-07	4,32E-07	1,99E-10	1,80E-09	4,21E-07	5,07E-06	1,95E+02	3,57E+00	3,22E+01	4,56E-01	2,10E+01	2,52E+02
SK	6,29E-06	1,38E-07	9,35E-07	3,56E-10	1,74E-09	4,66E-07	7,83E-06	3,04E+02	9,29E+00	9,60E+01	1,08E+00	4,41E+01	4,55E+02
GB	1,18E-04	4,19E-06	1,47E-05	5,56E-09	6,01E-08	1,72E-05	1,55E-04	5,16E+03	1,54E+02	1,42E+03	3,53E+01	8,39E+02	7,61E+03
NO	1,41E-05	4,26E-07	1,64E-06	1,08E-09	8,21E-09	1,59E-06	1,78E-05	1,22E+03	1,73E+01	1,15E+02	1,08E+01	1,01E+02	1,47E+03
AVG	3,98E-05	9,18E-07	3,66E-06	2,41E-09	1,33E-08	4,46E-06	4,88E-05	3,20E+02	2,06E+02	8,65E+00	4,27E+01	1,49E+03	2,07E+03
SUM	1,15E-03	2,66E-05	1,06E-04	6,98E-08	3,86E-07	1,29E-04	1,42E-03	9,29E+03	5,96E+03	2,51E+02	1,24E+03	4,32E+04	6,00E+04

Table S16: 2010 per capita biodiversity footprints LC-Impact footprints are measured in [PDF.yr] whereas ReCiPe footprints are measured in [species.yr]. The impact categories follow the description in section SI8. Categories like Land or Toxicity cover all the relevant sub-categories. TOTAL sums up all impacts per impact assessment method. AVG denotes the average.

	LC-Impact							**ReCiPe**					
	Land	Water	Glob. warm.	POCP	Eutroph.	Terr. acid.	TOTAL	Land	Water	Glob. warm.	Toxicity	Terr. acid.	TOTAL
AT	2,04E-12	4,22E-14	2,49E-13	1,23E-16	7,33E-16	2,17E-13	2,55E-12	1,96E-05	1,13E-05	3,58E-07	1,90E-06	9,07E-05	1,24E-04
BE	2,71E-12	9,22E-14	2,63E-13	9,86E-17	1,19E-15	3,31E-13	3,40E-12	2,02E-05	1,45E-05	4,24E-07	3,86E-06	1,01E-04	1,40E-04
BG	7,94E-13	1,40E-14	1,51E-13	1,08E-16	1,80E-16	1,92E-13	1,15E-12	1,73E-05	1,94E-05	1,95E-07	8,96E-07	6,04E-05	9,81E-05
CY	2,28E-12	8,82E-14	3,00E-13	7,92E-16	7,19E-16	9,28E-13	3,59E-12	2,66E-05	2,65E-05	4,03E-06	4,16E-06	9,60E-05	1,57E-04
CZ	8,89E-13	2,37E-14	2,00E-13	7,02E-17	2,76E-16	1,34E-13	1,25E-12	2,09E-05	1,03E-05	1,68E-07	1,19E-06	5,14E-05	8,40E-05
DE	1,83E-12	6,80E-14	2,13E-13	1,27E-16	9,53E-16	2,23E-13	2,33E-12	1,98E-05	1,13E-05	5,64E-07	2,31E-06	7,36E-05	1,08E-04
DK	1,59E-12	4,30E-14	2,71E-13	1,50E-16	6,47E-16	2,58E-13	2,17E-12	2,15E-05	1,95E-05	1,80E-06	2,19E-06	9,67E-05	1,42E-04
EE	1,13E-12	2,14E-14	2,11E-13	7,83E-17	5,12E-16	8,02E-14	1,44E-12	2,27E-05	1,39E-05	3,95E-07	1,05E-06	1,05E-04	1,43E-04
ES	4,25E-12	6,63E-14	1,70E-13	1,97E-16	8,43E-16	1,82E-13	4,67E-12	1,32E-05	8,48E-06	2,39E-07	3,94E-06	8,85E-05	1,14E-04
FI	1,26E-12	3,90E-14	3,27E-13	1,04E-16	7,45E-16	1,98E-13	1,83E-12	3,00E-05	1,42E-05	6,91E-07	1,98E-06	2,17E-04	2,64E-04
FR	2,22E-12	3,86E-14	1,85E-13	1,23E-16	6,93E-16	1,50E-13	2,60E-12	1,45E-05	1,07E-05	2,49E-07	1,93E-06	8,36E-05	1,11E-04
GR	4,14E-12	7,42E-14	3,30E-13	7,72E-16	6,31E-16	8,64E-13	5,41E-12	3,00E-05	2,99E-05	4,01E-06	5,10E-06	1,04E-04	1,73E-04
HR	1,95E-12	1,94E-14	1,38E-13	9,85E-17	4,55E-16	9,56E-14	2,21E-12	9,41E-06	6,18E-06	2,08E-07	9,47E-07	9,47E-05	1,11E-04
HU	6,04E-13	1,51E-14	1,39E-13	5,98E-17	1,67E-16	5,21E-14	8,11E-13	1,06E-05	5,19E-06	1,02E-07	7,33E-07	4,52E-05	6,18E-05
IE	1,62E-12	7,53E-14	2,59E-13	9,05E-17	9,07E-16	2,18E-13	2,17E-12	2,28E-05	1,43E-05	3,84E-07	2,41E-06	9,92E-05	1,39E-04
IT	3,27E-12	5,48E-14	2,28E-13	1,62E-16	9,08E-16	6,08E-13	4,16E-12	1,77E-05	1,09E-05	4,83E-07	2,96E-06	8,46E-05	1,17E-04
LT	1,00E-12	4,40E-14	1,68E-13	6,75E-17	3,41E-16	7,34E-14	1,29E-12	1,48E-05	9,34E-06	2,36E-07	1,11E-06	1,27E-04	1,53E-04
LU	5,20E-12	1,83E-13	4,20E-13	1,53E-16	2,01E-15	6,83E-13	6,49E-12	2,94E-05	2,02E-05	7,41E-07	9,25E-06	1,98E-04	2,58E-04
LV	5,40E-13	1,95E-14	1,55E-13	6,78E-17	2,72E-16	1,11E-13	8,26E-13	1,15E-05	8,90E-06	2,15E-07	6,95E-07	9,39E-05	1,15E-04
MT	1,56E-12	4,19E-14	3,21E-13	1,39E-16	4,88E-16	2,89E-13	2,21E-12	1,86E-05	1,09E-05	4,19E-07	1,73E-06	5,70E-05	8,87E-05
NL	3,20E-12	8,37E-14	2,73E-13	8,72E-17	1,36E-15	3,69E-13	3,92E-12	2,13E-05	1,29E-05	3,54E-07	3,49E-06	1,03E-04	1,41E-04
PL	8,28E-13	2,11E-14	1,85E-13	7,53E-17	2,19E-16	5,86E-14	1,09E-12	2,09E-05	1,15E-05	1,55E-07	1,50E-06	5,74E-05	9,15E-05
PT	4,05E-12	4,47E-14	1,59E-13	2,15E-16	7,08E-16	1,38E-13	4,39E-12	1,33E-05	7,96E-06	2,25E-07	3,02E-06	8,59E-05	1,10E-04
RO	1,28E-12	1,26E-14	1,07E-13	7,33E-17	1,31E-16	5,41E-14	1,46E-12	9,14E-06	7,93E-06	1,07E-07	9,30E-07	7,53E-05	9,34E-05
SE	1,44E-12	4,85E-14	2,22E-13	8,99E-17	7,59E-16	2,04E-13	1,92E-12	1,86E-05	1,23E-05	5,51E-07	2,09E-06	1,53E-04	1,87E-04
SI	2,01E-12	5,18E-14	2,11E-13	9,73E-17	8,77E-16	2,05E-13	2,48E-12	1,57E-05	1,03E-05	2,23E-07	1,74E-06	9,52E-05	1,23E-04
SK	1,17E-12	2,55E-14	1,73E-13	6,61E-17	3,23E-16	8,64E-14	1,45E-12	1,78E-05	8,19E-06	2,00E-07	1,72E-06	5,64E-05	8,43E-05
GB	1,89E-12	6,67E-14	2,34E-13	8,86E-17	9,57E-16	2,73E-13	2,46E-12	2,26E-05	1,34E-05	5,63E-07	2,46E-06	8,23E-05	1,21E-04
NO	2,89E-12	8,71E-14	3,34E-13	2,21E-16	1,68E-15	3,26E-13	3,64E-12	2,35E-05	2,06E-05	2,20E-06	3,53E-06	2,50E-04	3,00E-04
AVG	2,06E-12	5,19E-14	2,27E-13	1,58E-16	7,14E-16	2,62E-13	2,60E-12	1,91E-05	1,31E-05	7,06E-07	2,44E-06	1,01E-04	1,36E-04

Table S17: Economic data for EU28 countries + Norway. The table shows data on populations, households, gross domestic product (GDP, absolute and per capita), and balanced consumer expenditure (BCE), all for the years 2005 and 2010 (including non-weighted totals and averages), as well as the growth in GDP in this period. Except for BCE, which was calculated in the present work, all these factors were provided by Tisserant (2018).

	Population		**Households**		**GDP [€]**		**GDP per capita [€]**		**BCE [€]**		**GDP growth 2005 - 2010**	
	2010	**2005**	**2010**	**2005**	**2010**	**2005**	**2010**	**2005**	**2010**	**2005**	**absolute**	**per capita**
AT	8,39E+06	8,23E+06	3,62E+06	3,47E+06	2,94E+11	2,53E+11	3,51E+04	3,07E+04	1,28E+11	1,12E+11	16,38%	14,14%
BE	1,09E+07	1,05E+07	4,62E+06	4,38E+06	3,65E+11	3,11E+11	3,34E+04	2,97E+04	1,48E+11	1,25E+11	17,15%	12,41%
BG	7,40E+06	7,74E+06	2,84E+06	2,87E+06	3,77E+10	2,40E+10	5,09E+03	3,10E+03	2,05E+10	1,45E+10	57,16%	64,47%
CY	1,10E+06	1,03E+06	2,85E+05	2,50E+05	1,91E+10	1,52E+10	1,73E+04	1,47E+04	1,08E+10	8,24E+09	26,06%	17,94%
CZ	1,05E+07	1,02E+07	4,42E+06	4,12E+06	1,56E+11	1,09E+11	1,49E+04	1,07E+04	6,14E+10	4,20E+10	42,86%	39,27%
DE	8,18E+07	8,25E+07	3,96E+07	3,85E+07	2,58E+12	2,30E+12	3,15E+04	2,79E+04	1,17E+12	1,01E+12	12,07%	13,02%
DK	5,55E+06	5,42E+06	2,31E+06	2,35E+06	2,41E+11	2,13E+11	4,35E+04	3,92E+04	9,75E+10	8,68E+10	13,44%	10,82%
EE	1,33E+06	1,35E+06	5,49E+02	5,76E+02	1,47E+10	1,13E+10	1,11E+04	8,31E+03	5,97E+09	5,06E+09	30,71%	33,00%
ES	4,66E+07	4,37E+07	1,76E+07	1,58E+07	1,08E+12	9,30E+11	2,32E+04	2,13E+04	5,13E+11	4,56E+11	16,09%	8,80%
FI	5,36E+06	5,25E+06	2,51E+06	2,40E+06	1,87E+11	1,64E+11	3,49E+04	3,13E+04	7,66E+10	6,43E+10	13,75%	11,27%
FR	6,50E+07	6,32E+07	2,72E+07	2,59E+07	2,00E+12	1,77E+12	3,07E+04	2,80E+04	8,63E+11	7,69E+11	12,72%	9,52%
GR	1,12E+07	1,11E+07	4,35E+06	4,22E+06	2,26E+11	1,99E+11	2,02E+04	1,80E+04	1,42E+11	1,18E+11	13,38%	12,77%
HR	4,42E+06	4,44E+06	1,52E+06	1,57E+06	4,50E+10	3,65E+10	1,02E+04	8,22E+03	2,18E+10	1,66E+10	23,29%	23,96%
HU	1,00E+07	1,01E+07	4,01E+06	3,82E+06	9,81E+10	9,05E+10	9,81E+03	8,97E+03	4,03E+10	3,95E+10	8,49%	9,43%
IE	4,56E+06	4,16E+06	1,69E+06	0	1,66E+11	1,70E+11	3,64E+04	4,08E+04	6,22E+10	0	-2,30%	-10,88%
IT	5,93E+07	5,80E+07	2,47E+07	2,32E+07	1,60E+12	1,49E+12	2,71E+04	2,57E+04	8,33E+11	6,19E+11	7,68%	5,30%
LT	3,10E+06	3,32E+06	1,35E+06	1,18E+06	2,80E+10	2,10E+10	9,04E+03	6,32E+03	1,69E+10	1,25E+10	33,29%	42,99%
LU	5,07E+05	4,65E+05	2,05E+05	1,81E+05	3,95E+10	2,97E+10	7,79E+04	6,39E+04	9,90E+09	8,59E+09	32,86%	21,91%
LV	2,10E+06	2,24E+06	8,09E+05	8,06E+05	1,79E+10	1,36E+10	8,54E+03	6,07E+03	9,45E+09	7,05E+09	31,82%	40,70%
MT	4,15E+05	4,04E+05	1,37E+05	1,29E+05	6,59E+09	5,14E+09	1,59E+04	1,27E+04	2,92E+09	2,58E+09	28,30%	25,00%
NL	1,66E+07	1,63E+07	7,34E+06	7,01E+06	6,31E+11	5,45E+11	3,80E+04	3,34E+04	2,30E+11	2,28E+11	15,68%	13,62%
PL	3,82E+07	3,82E+07	1,33E+07	1,27E+07	3,62E+11	2,45E+11	9,47E+03	6,41E+03	1,84E+11	1,29E+11	47,74%	47,67%
PT	1,06E+07	1,05E+07	3,94E+06	3,77E+06	1,80E+11	1,59E+11	1,70E+04	1,51E+04	9,49E+10	8,26E+10	13,35%	12,60%
RO	2,02E+07	2,13E+07	7,40E+06	7,36E+06	1,27E+11	8,01E+10	6,26E+03	3,76E+03	7,38E+10	4,84E+10	58,13%	66,51%
SE	9,38E+06	9,03E+06	4,46E+03	0	3,68E+11	3,13E+11	3,93E+04	3,46E+04	1,55E+11	0	17,81%	13,43%
SI	2,05E+06	2,00E+06	8,07E+02	8,07E+02	3,62E+10	2,92E+10	1,77E+04	1,46E+04	1,61E+10	1,31E+10	23,97%	21,06%
SK	5,39E+06	5,37E+06	1,75E+06	1,67E+06	6,73E+10	3,92E+10	1,25E+04	7,30E+03	3,20E+10	1,89E+10	71,61%	71,02%
GB	6,28E+07	6,04E+07	2,72E+07	2,61E+07	1,81E+12	1,94E+12	2,89E+04	3,22E+04	9,43E+11	1,01E+12	-6,75%	-10,27%
NO	4,89E+06	4,62E+06	2,17E+06	2,02E+06	3,23E+11	2,48E+11	6,61E+04	5,37E+04	9,81E+10	7,87E+10	30,26%	23,18%
Average	1,76E+07	1,73E+07	7,14E+06	7,25E+06	4,52E+11	4,06E+11	2,52E+04	2,20E+04	2,09E+11	1,90E+11	24,38%	22,92%
SUM	5,10E+08	5,01E+08	2,07E+08	1,96E+08	1,31E+13	1,18E+13	7,31E+05	6,37E+05	6,06E+12	5,12E+12	11,45%	14,76%

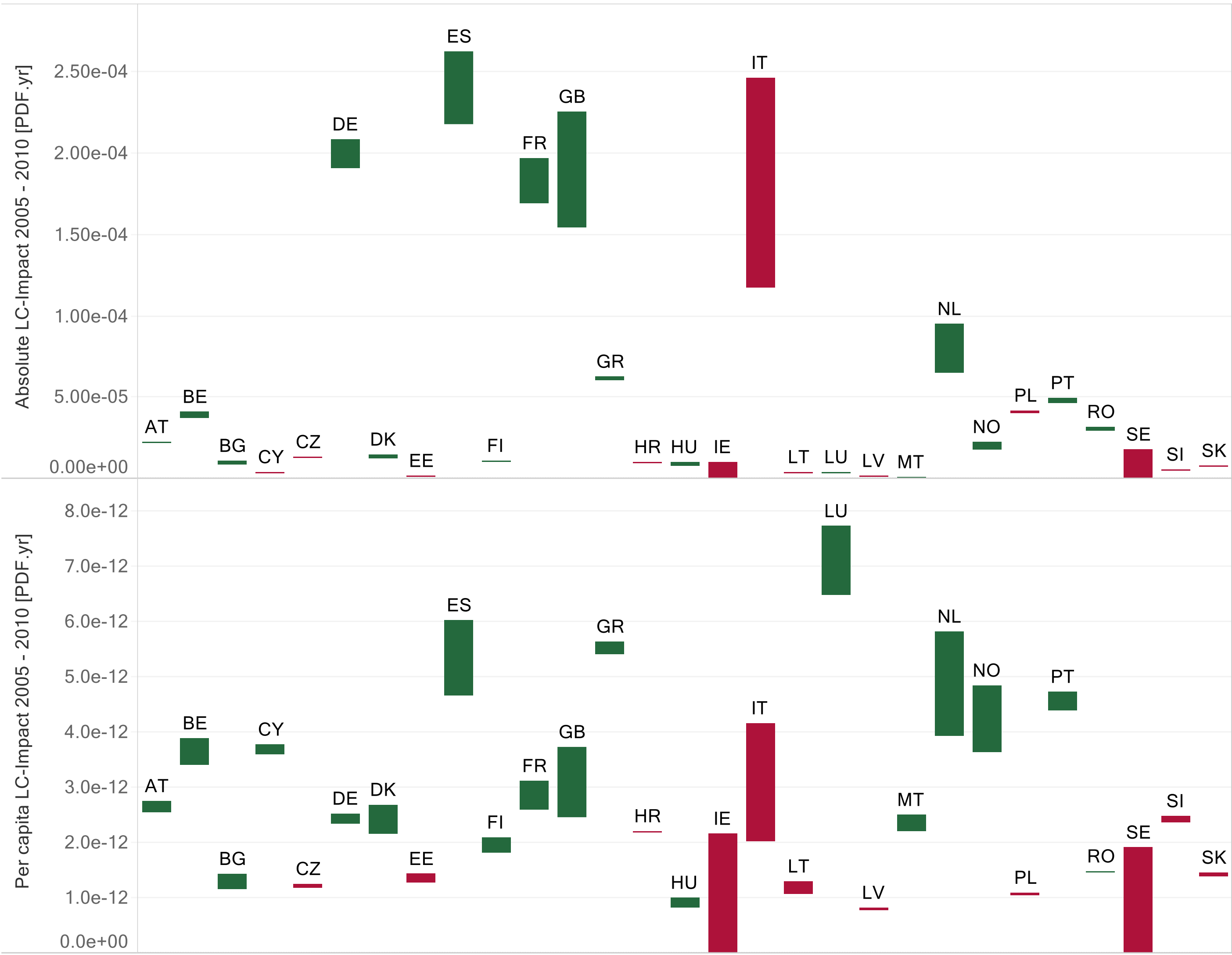

Figure S5: Difference of national LC-Impact biodiversity footprints between 2005 and 2010. Red bars mark increases from 2005 to 2010, whereas green ones indicate decreases. No 2005 data was available for Ireland and Sweden.

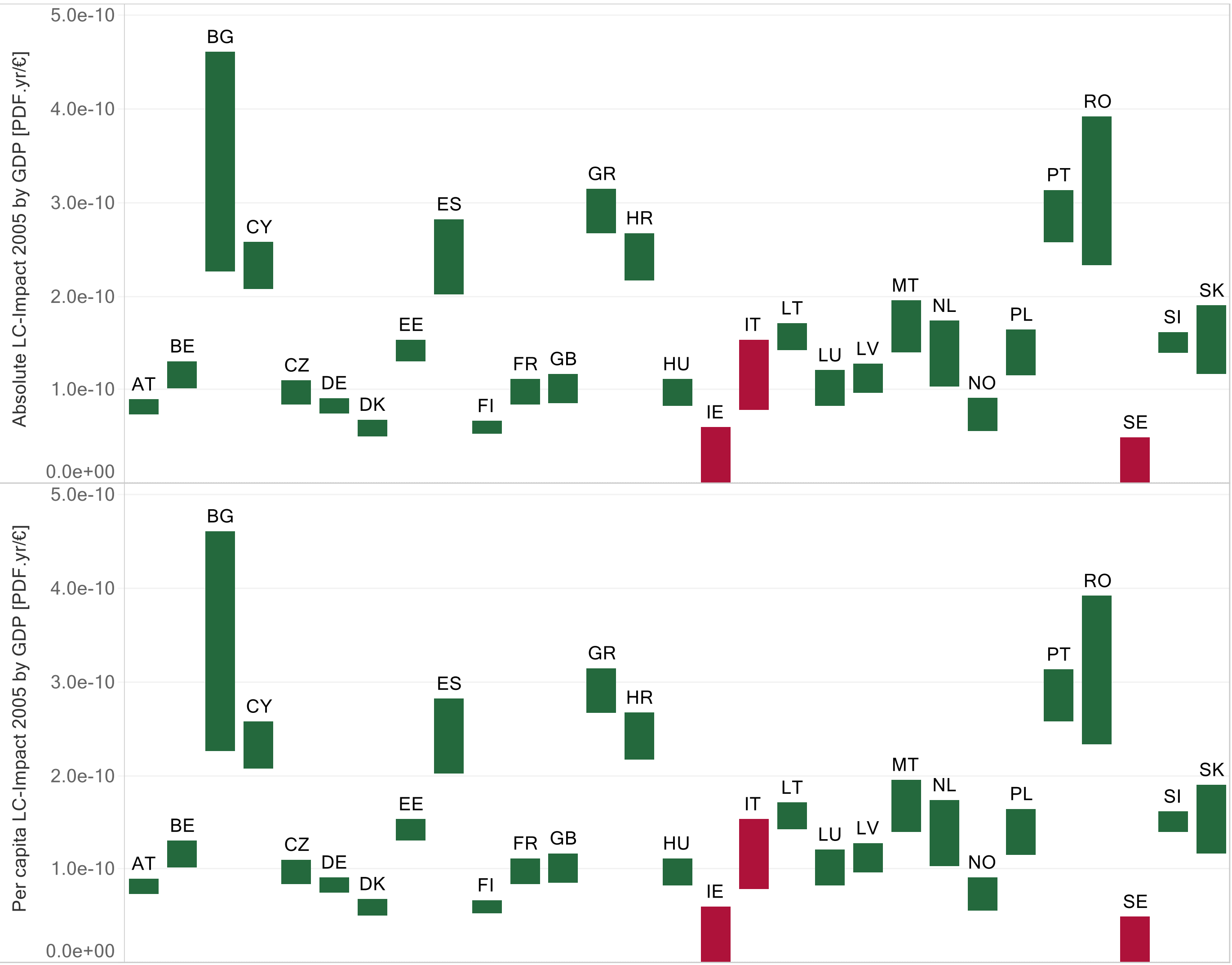

Figure S6: Difference of national LC-Impact biodiversity footprints between 2005 and 2010 normalised against the respective gross domestic product. Red bars mark increases from 2005 to 2010, whereas green ones indicate decreases. No 2005 data was available for Ireland and Sweden.

Table S18: Absolute difference in national biodiversity footprints between 2005 and 2010. Fields labelled green indicate decreases from 2005 to 2010, whereas red ones highlight increases. The total covers only the here depicted impact categories, with white fields showing decreases and yellow ones increases. The unit for LC-Impact values is [PDF.yr], whereas the one for ReCiPe ones is [species.yr].

	Land occ.	**Water stress**	**Glob. warm.**	**Terr. acid.**	**TOTAL**	**Land occ.**	**Water stress**	**Glob. warm.**	**Terr. acid.**	**TOTAL**
Country	LC-Impact	LC-Impact	LC-Impact	LC-Impact	LC-Impact	ReCiPe	ReCiPe	ReCiPe	ReCiPe	ReCiPe
AT	-1,21E-06	-1,31E-07	-2,35E-07	3,92E-07	-1,18E-06	-1,04E+02	-1,04E+00	-1,34E+01	5,97E+00	-1,12E+02
BE	-4,02E-06	-6,76E-08	-1,37E-07	6,75E-07	-3,55E-06	-1,13E+02	-4,15E-02	-7,45E+00	1,07E+01	-1,10E+02
BG	-2,34E-06	3,55E-08	1,39E-07	-3,71E-07	-2,54E-06	-6,26E+01	1,67E+00	1,38E+01	-4,14E+01	-8,86E+01
CY	-2,59E-07	2,18E-09	3,27E-08	2,84E-07	5,95E-08	-1,64E+01	5,46E-01	3,72E+00	5,20E+00	-6,89E+00
CZ	3,27E-07	-7,94E-08	1,32E-08	8,19E-07	1,08E-06	3,47E+01	1,93E+00	2,58E+01	1,91E+01	8,15E+01
DE	-1,76E-05	-1,15E-06	-1,02E-06	2,32E-06	-1,75E-05	-6,21E+02	6,36E+00	-3,32E+01	4,73E+01	-6,01E+02
DK	-2,17E-06	-1,86E-07	-1,74E-07	5,29E-09	-2,52E-06	-1,09E+02	3,62E-01	-6,98E+00	2,28E+00	-1,13E+02
EE	2,43E-07	3,74E-09	-7,01E-08	1,73E-08	1,94E-07	-6,98E+01	9,69E-02	-2,88E+00	-2,44E+00	-7,50E+01
ES	-4,02E-05	-1,13E-06	-2,66E-06	-1,09E-06	-4,50E-05	-1,27E+03	-7,12E+00	-2,05E+02	-2,00E+02	-1,69E+03
FI	-1,19E-06	-3,59E-08	-8,28E-08	1,93E-07	-1,12E-06	-3,02E+02	-8,56E-01	1,28E+01	1,89E+00	-2,88E+02
FR	-2,60E-05	-7,91E-07	-1,86E-06	6,11E-07	-2,81E-05	-1,02E+03	-2,49E+01	-9,57E+01	-3,59E+01	-1,17E+03
GR	2,56E-06	-4,93E-07	-4,81E-07	-3,88E-06	-2,30E-06	-2,28E+02	-1,05E+01	-1,76E+01	-2,00E+02	-4,56E+02
HR	-1,54E-07	-1,38E-08	1,17E-07	5,76E-08	6,53E-09	3,15E+01	6,93E-01	-2,47E-01	-1,07E+00	3,09E+01
HU	-1,65E-06	-2,48E-08	-3,55E-07	3,08E-08	-2,00E-06	-1,19E+02	-1,25E+00	-3,62E+01	-1,61E+01	-1,72E+02
IE	7,38E-06	3,43E-07	1,18E-06	9,93E-07	9,89E-06	4,52E+02	1,10E+01	1,04E+02	6,52E+01	6,33E+02
IT	1,07E-04	2,24E-06	1,22E-06	1,84E-05	1,29E-04	1,72E+03	1,25E+02	1,63E+02	2,42E+02	2,25E+03
LT	3,33E-07	-9,38E-08	9,07E-08	6,31E-08	3,93E-07	2,44E+01	2,05E-01	3,84E+00	5,92E-01	2,90E+01
LU	-3,28E-07	-1,96E-09	-1,32E-09	2,61E-08	-3,05E-07	-1,05E+01	8,11E-03	2,65E-01	9,92E-01	-9,19E+00
LV	-1,86E-07	7,00E-09	4,48E-08	1,38E-07	3,76E-09	-7,64E+01	-2,74E-01	2,75E+00	4,27E+00	-6,96E+01
MT	-7,28E-08	-1,59E-09	1,15E-08	-2,61E-08	-8,90E-08	-3,69E+00	-9,16E-02	-6,02E-01	-8,44E-01	-5,23E+00
NL	-2,86E-05	-8,02E-07	-8,03E-07	5,28E-07	-2,97E-05	-7,03E+02	-4,61E+00	-4,90E+01	-1,78E+01	-7,75E+02
PL	7,03E-07	6,60E-08	-1,29E-09	7,53E-07	1,52E-06	3,44E+01	9,17E+00	2,82E+01	-4,18E+01	3,00E+01
PT	-2,54E-06	-3,02E-07	-3,55E-07	1,73E-08	-3,18E-06	-1,34E+02	2,93E+00	-2,95E+01	-9,15E+00	-1,69E+02
RO	-1,42E-06	-3,12E-07	-4,00E-07	2,03E-07	-1,92E-06	1,88E+02	-3,43E+00	-2,53E+01	-2,96E+01	1,29E+02
SE	1,35E-05	4,55E-07	2,08E-06	1,91E-06	1,80E-05	1,43E+03	1,96E+01	1,75E+02	1,15E+02	1,74E+03
SI	1,44E-07	4,80E-08	-5,30E-09	1,77E-07	3,64E-07	6,52E+00	7,32E-01	-4,49E+00	-3,79E+00	-1,02E+00
SK	8,32E-08	2,40E-08	6,89E-08	2,01E-07	3,78E-07	5,35E+00	9,20E-01	6,78E+00	5,42E+00	1,85E+01
GB	-6,12E-05	-1,09E-06	-5,24E-06	-3,39E-06	-7,09E-05	-2,01E+03	-2,90E+01	-3,60E+02	-1,89E+02	-2,59E+03
NO	-4,27E-06	-1,52E-08	-3,92E-07	3,78E-08	-4,64E-06	-1,65E+02	-7,51E-01	3,73E+00	1,27E+01	-1,49E+02

Table S19: Per capita differences in national biodiversity footprints between 2005 and 2010. Fields labelled green indicate decreases from 2005 to 2010, whereas red ones highlight increases. The total covers only the here depicted impact categories, with white fields showing decreases and yellow ones increases. The unit for LC-Impact values is [PDF.yr], whereas the one for ReCiPe ones is [species.yr].

	Land occ.	**Water stress**	**Glob. warm.**	**Terr. acid.**	**TOTAL**	**Land occ.**	**Water stress**	**Glob. warm.**	**Terr. acid.**	**TOTAL**
Country	LC-Impact	LC-Impact	LC-Impact	LC-Impact	LC-Impact	ReCiPe	ReCiPe	ReCiPe	ReCiPe	ReCiPe
AT	-1,87E-13	-1,67E-14	-3,35E-14	4,34E-14	-1,94E-13	-1,44E-05	-1,64E-07	-2,01E-06	5,03E-07	-1,60E-05
BE	-4,98E-13	-1,03E-14	-2,42E-14	5,05E-14	-4,82E-13	-1,51E-05	-1,67E-07	-1,56E-06	4,13E-07	-1,64E-05
BG	-2,67E-13	5,21E-15	2,46E-14	-3,93E-14	-2,77E-13	-5,40E-06	2,56E-07	2,55E-06	-4,49E-06	-7,09E-06
CY	-4,08E-13	-3,95E-15	1,11E-14	2,11E-13	-1,90E-13	-2,24E-05	2,43E-07	1,77E-06	3,21E-06	-1,72E-05
CZ	9,12E-15	-8,39E-15	-3,85E-15	7,67E-14	7,36E-14	2,07E-06	1,59E-07	1,99E-06	1,61E-06	5,83E-06
DE	-1,98E-13	-1,34E-14	-1,06E-14	3,00E-14	-1,92E-13	-6,91E-06	9,65E-08	-2,37E-07	6,69E-07	-6,38E-06
DK	-4,37E-13	-3,54E-14	-3,86E-14	-5,13E-15	-5,16E-13	-2,24E-05	1,50E-08	-1,80E-06	-3,92E-08	-2,42E-05
EE	1,99E-13	3,13E-15	-4,81E-14	1,42E-14	1,68E-13	-4,97E-05	8,95E-08	-1,74E-06	-1,56E-06	-5,29E-05
ES	-1,20E-12	-3,03E-14	-7,22E-14	-3,73E-14	-1,34E-12	-3,51E-05	-4,27E-07	-5,58E-06	-5,14E-06	-4,63E-05
FI	-2,55E-13	-7,71E-15	-2,31E-14	3,24E-14	-2,54E-13	-6,24E-05	-2,07E-07	1,77E-06	4,22E-08	-6,08E-05
FR	-4,77E-13	-1,36E-14	-3,48E-14	5,28E-15	-5,20E-13	-1,86E-05	-4,51E-07	-1,94E-06	-8,81E-07	-2,18E-05
GR	2,08E-13	-4,48E-14	-4,51E-14	-3,55E-13	-2,36E-13	-2,11E-05	-9,71E-07	-1,75E-06	-1,82E-05	-4,20E-05
HR	-2,40E-14	-3,00E-15	2,70E-14	1,35E-14	1,35E-14	7,62E-06	1,61E-07	-4,30E-09	-2,06E-07	7,57E-06
HU	-1,58E-13	-2,33E-15	-3,40E-14	3,50E-15	-1,91E-13	-1,14E-05	-1,18E-07	-3,50E-06	-1,55E-06	-1,66E-05
IE	1,62E-12	7,53E-14	2,59E-13	2,18E-13	2,17E-12	9,92E-05	2,41E-06	2,28E-05	1,43E-05	1,39E-04
IT	1,77E-12	3,73E-14	1,60E-14	3,03E-13	2,13E-12	2,77E-05	2,09E-06	2,41E-06	3,93E-06	3,61E-05
LT	1,68E-13	-2,52E-14	3,87E-14	2,40E-14	2,05E-13	1,60E-05	1,37E-07	2,16E-06	8,11E-07	1,91E-05
LU	-1,17E-12	-2,06E-14	-4,06E-14	-5,27E-15	-1,24E-12	-4,03E-05	-8,14E-07	-2,07E-06	3,20E-07	-4,28E-05
LV	-4,92E-14	4,35E-15	2,98E-14	6,88E-14	5,37E-14	-2,82E-05	-7,84E-08	1,96E-06	2,47E-06	-2,38E-05
MT	-2,21E-13	-5,04E-15	1,99E-14	-7,23E-14	-2,79E-13	-1,06E-05	-2,73E-07	-1,98E-06	-2,38E-06	-1,53E-05
NL	-1,81E-12	-5,07E-14	-5,41E-14	2,57E-14	-1,89E-12	-4,50E-05	-3,46E-07	-3,39E-06	-1,32E-06	-5,00E-05
PL	1,80E-14	1,72E-15	-1,22E-16	1,97E-14	3,93E-14	8,73E-07	2,40E-07	7,30E-07	-1,10E-06	7,42E-07
PT	-2,69E-13	-2,90E-14	-3,48E-14	7,30E-16	-3,32E-13	-1,33E-05	2,59E-07	-2,90E-06	-9,24E-07	-1,68E-05
RO	-1,83E-15	-1,40E-14	-1,34E-14	1,22E-14	-1,70E-14	1,26E-05	-1,14E-07	-7,28E-07	-9,89E-07	1,08E-05
SE	1,44E-12	4,85E-14	2,22E-13	2,04E-13	1,92E-12	1,53E-04	2,09E-06	1,86E-05	1,23E-05	1,86E-04
SI	2,37E-14	2,27E-14	-7,71E-15	8,36E-14	1,22E-13	9,71E-07	3,24E-07	-2,62E-06	-2,14E-06	-3,47E-06
SK	1,14E-14	4,37E-15	1,22E-14	3,72E-14	6,52E-14	8,00E-07	1,65E-07	1,20E-06	9,81E-07	3,15E-06
GB	-1,09E-12	-2,07E-14	-9,59E-14	-6,68E-14	-1,27E-12	-3,65E-05	-5,76E-07	-6,85E-06	-3,65E-06	-4,76E-05
NO	-1,09E-12	-8,30E-15	-1,04E-13	-1,06E-14	-1,21E-12	-5,00E-05	-3,66E-07	-5,42E-07	1,57E-06	-4,93E-05

Table S20: Descriptive statistics for LC-Impact and ReCiPe biodiversity footprints across common impact categories for both reference years. The statistics comprise mean, median, maximum (max), minimum (min), and the standard deviation (std). Mind that the given statistics for the totals do not include other impact categories that are otherwise covered by each footprint type respectively. The unit for LC-Impact values is [PDF.yr], whereas the one for ReCiPe ones is [species.yr]. GHG – greenhouse gases; TOTAL – sum of impacts in preceding categories.

Year	Source	Footprint type	Absolute					Per capita				
			Mean	Median	Max	Min	Std	Mean	Median	Max	Min	Std
2010	Land occupation average	LC-Impact	3,98E-05	9,31E-06	1,98E-04	6,47E-07	5,83E-05	2,06E-12	1,83E-12	5,20E-12	5,40E-13	1,19E-12
2010	Water stress	LC-Impact	9,18E-07	2,55E-07	5,56E-06	1,74E-08	1,39E-06	5,19E-14	4,40E-14	1,83E-13	1,26E-14	3,45E-14
2010	GHG	LC-Impact	3,66E-06	1,68E-06	1,75E-05	1,33E-07	4,73E-06	2,27E-13	2,13E-13	4,20E-13	1,07E-13	7,22E-14
2010	Acidification	LC-Impact	4,46E-06	1,42E-06	3,61E-05	1,07E-07	7,63E-06	2,62E-13	2,04E-13	9,28E-13	5,21E-14	2,26E-13
2010	TOTAL	LC-Impact	4,88E-05	1,31E-05	2,46E-04	9,17E-07	7,04E-05	2,60E-12	2,21E-12	6,49E-12	8,10E-13	1,41E-12
2010	Land occupation average	ReCiPe	1,49E+03	7,61E+02	6,02E+03	2,36E+01	1,77E+03	1,01E-04	9,39E-05	2,50E-04	4,52E-05	4,72E-05
2010	Water stress	ReCiPe	4,27E+01	1,25E+01	1,89E+02	7,19E-01	5,91E+01	2,44E-06	1,98E-06	9,25E-06	6,95E-07	1,71E-06
2010	GHG	ReCiPe	3,20E+02	1,41E+02	1,62E+03	7,73E+00	4,24E+02	1,91E-05	1,96E-05	3,00E-05	9,14E-06	5,66E-06
2010	Acidification	ReCiPe	2,06E+02	1,01E+02	9,27E+02	4,52E+00	2,56E+02	1,31E-05	1,13E-05	2,99E-05	5,19E-06	5,67E-06
2010	TOTAL	ReCiPe	2,06E+03	1,04E+03	8,75E+03	3,66E+01	2,48E+03	1,36E-04	1,21E-04	2,98E-04	6,17E-05	5,39E-05
2005	Land occupation average	LC-Impact	4,50E-05	1,10E-05	2,38E-04	7,20E-07	6,48E-05	2,37E-12	1,98E-12	6,37E-12	5,90E-13	1,54E-12
2005	Water stress	LC-Impact	1,12E-06	4,25E-07	6,72E-06	1,90E-08	1,71E-06	6,17E-14	5,23E-14	2,03E-13	8,79E-15	4,49E-14
2005	GHG	LC-Impact	4,28E-06	2,03E-06	1,99E-05	1,21E-07	5,58E-06	2,46E-13	2,24E-13	4,61E-13	1,11E-13	9,37E-14
2005	Acidification	LC-Impact	4,05E-06	1,43E-06	2,05E-05	8,94E-08	5,97E-06	2,49E-13	1,74E-13	1,22E-12	3,88E-14	2,58E-13
2005	TOTAL	LC-Impact	5,45E-05	1,45E-05	2,63E-04	1,01E-06	7,63E-05	2,93E-12	2,49E-12	7,73E-12	7,71E-13	1,81E-12
2005	Land occupation average	ReCiPe	1,72E+03	8,64E+02	7,17E+03	2,73E+01	2,11E+03	1,15E-04	1,05E-04	3,00E-04	4,93E-05	6,32E-05
2005	Water stress	ReCiPe	4,22E+01	1,18E+01	1,90E+02	8,11E-01	5,93E+01	2,49E-06	2,06E-06	1,01E-05	6,40E-07	2,02E-06
2005	GHG	ReCiPe	3,57E+02	1,48E+02	1,78E+03	8,33E+00	4,78E+02	1,99E-05	2,00E-05	3,17E-05	9,41E-06	6,18E-06
2005	Acidification	ReCiPe	2,30E+02	8,91E+01	1,03E+03	5,36E+00	2,84E+02	1,42E-05	1,26E-05	4,81E-05	6,39E-06	8,28E-06
2005	TOTAL	ReCiPe	2,35E+03	1,15E+03	1,02E+04	4,18E+01	2,90E+03	1,52E-04	1,34E-04	3,47E-04	7,80E-05	7,14E-05

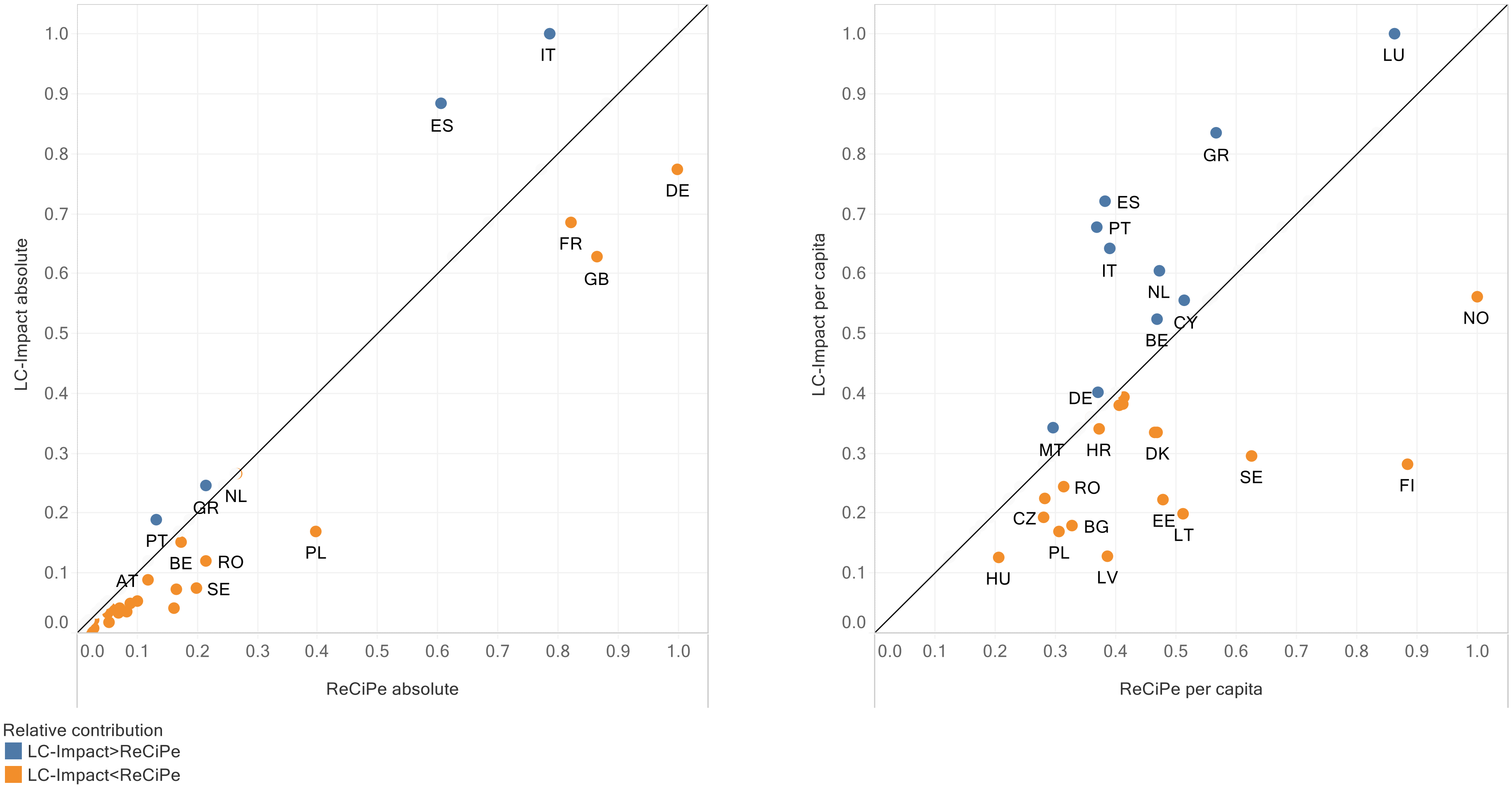

Figure S7: Comparison of biodiversity footprint types on both absolute and per capita level for 2010. The footprints are normalised against the maximum footprint per footprint type, e.g. Italy for absolute LC-Impact footprints.

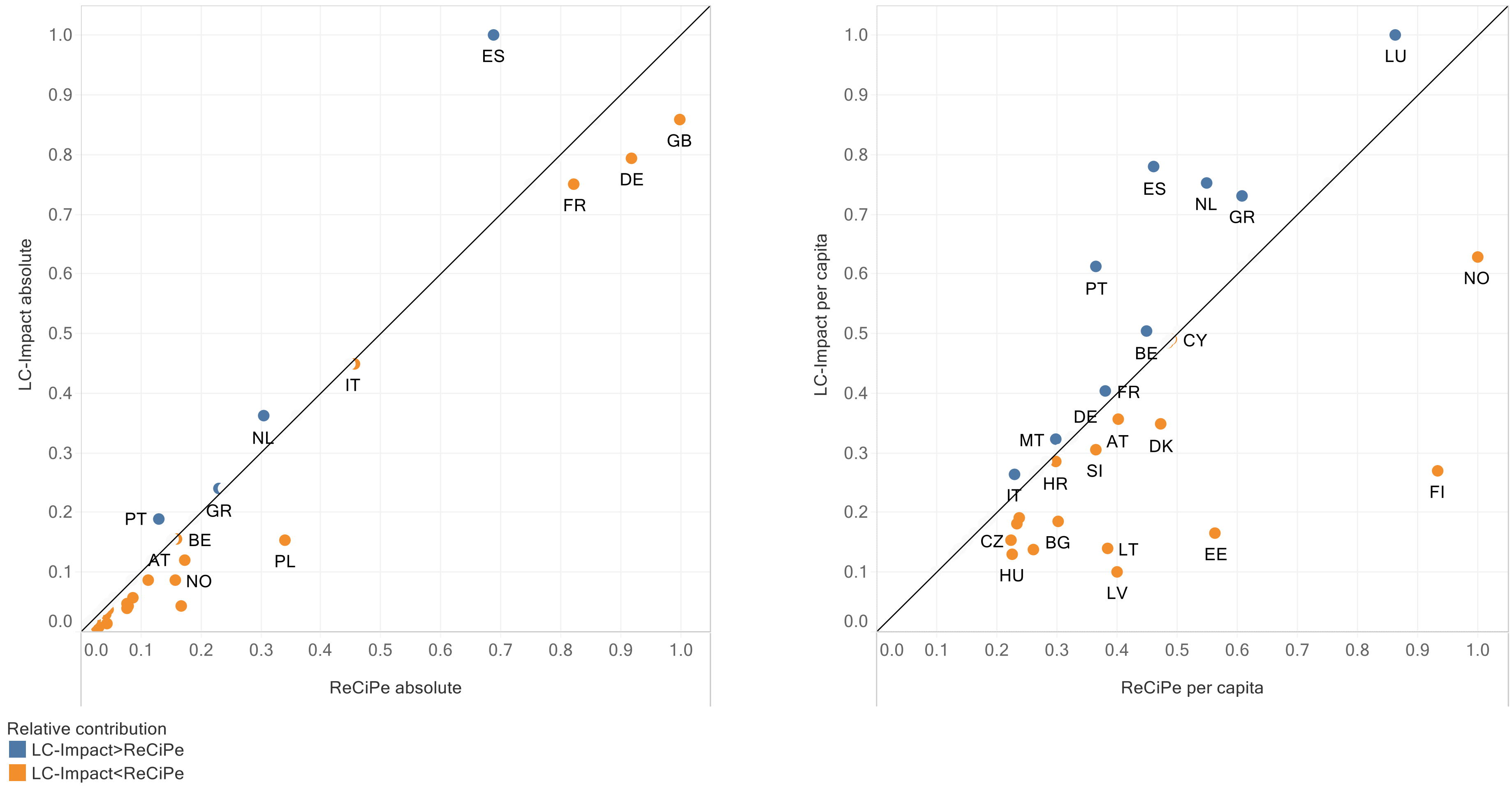

Figure S8: Comparison of biodiversity footprint types on both absolute and per capita level for 2005. The footprints are normalised against the maximum footprint per footprint type, e.g. Spain for absolute LC-Impact footprints.

Table S21: Relative contribution of impact category to total impact according to LC-Impact for 2005 and 2010. The values sum per country and year up to 100%. Shading indicates the magnitude of contribution in comparison across the countries, i.e. the darker the shade, the higher this country's relative contribution for the selected impact category. No data was available for Ireland and Sweden in 2005.

LC-Impact

	2010						2005					
	Land occ.	Water stress	Glob. warm.	POCP	FW Eutroph.	Terr. acid.	Land occ.	Water stress	Glob. warm.	POCP	FW Eutroph.	Terr. acid.
AT	80,01%	1,66%	9,77%	0,00%	0,03%	8,52%	81,17%	2,15%	10,31%	0,01%	0,03%	6,34%
BE	79,80%	2,71%	7,73%	0,00%	0,04%	9,73%	82,72%	2,64%	7,39%	0,00%	0,03%	7,22%
BG	68,99%	1,22%	13,10%	0,01%	0,02%	16,67%	74,32%	0,62%	8,83%	0,01%	0,03%	16,19%
CY	63,34%	2,45%	8,33%	0,02%	0,02%	25,83%	70,94%	2,43%	7,62%	0,01%	0,02%	18,96%
CZ	71,29%	1,90%	16,01%	0,01%	0,02%	10,77%	74,99%	2,74%	17,34%	0,01%	0,02%	4,91%
DE	78,31%	2,92%	9,15%	0,01%	0,04%	9,57%	80,20%	3,22%	8,87%	0,01%	0,04%	7,65%
DK	73,56%	1,99%	12,51%	0,01%	0,03%	11,91%	75,69%	2,92%	11,54%	0,01%	0,03%	9,81%
EE	78,23%	1,49%	14,67%	0,01%	0,04%	5,57%	72,94%	1,44%	20,40%	0,01%	0,02%	5,19%
ES	91,04%	1,42%	3,63%	0,00%	0,02%	3,89%	90,71%	1,61%	4,02%	0,01%	0,02%	3,64%
FI	69,07%	2,14%	17,91%	0,01%	0,04%	10,84%	72,92%	2,25%	16,84%	0,01%	0,04%	7,95%
FR	85,57%	1,49%	7,12%	0,00%	0,03%	5,78%	86,59%	1,68%	7,05%	0,00%	0,03%	4,65%
GR	76,52%	1,37%	6,11%	0,01%	0,01%	15,97%	69,62%	2,11%	6,65%	0,02%	0,01%	21,59%
HR	88,52%	0,88%	6,24%	0,00%	0,02%	4,33%	90,15%	1,02%	5,05%	0,00%	0,03%	3,74%
HU	74,54%	1,86%	17,14%	0,01%	0,02%	6,43%	76,11%	1,74%	17,27%	0,01%	0,02%	4,85%
IE	74,53%	3,47%	11,93%	0,00%	0,04%	10,03%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
IT	78,55%	1,32%	5,48%	0,00%	0,02%	14,63%	73,65%	0,86%	10,43%	0,01%	0,02%	15,03%
LT	77,79%	3,43%	13,05%	0,01%	0,03%	5,71%	77,03%	6,42%	11,95%	0,01%	0,02%	4,58%
LU	80,15%	2,81%	6,48%	0,00%	0,03%	10,53%	82,47%	2,63%	5,96%	0,00%	0,03%	8,91%
LV	65,46%	2,36%	18,72%	0,01%	0,03%	13,41%	76,41%	1,96%	16,17%	0,01%	0,02%	5,43%
MT	70,54%	1,89%	14,49%	0,01%	0,02%	13,05%	71,53%	1,88%	12,07%	0,01%	0,03%	14,49%
NL	81,48%	2,13%	6,95%	0,00%	0,03%	9,40%	86,13%	2,31%	5,62%	0,00%	0,03%	5,91%
PL	75,78%	1,93%	16,91%	0,01%	0,02%	5,36%	76,90%	1,84%	17,55%	0,01%	0,02%	3,69%
PT	92,20%	1,02%	3,62%	0,00%	0,02%	3,14%	91,41%	1,56%	4,10%	0,01%	0,02%	2,90%
RO	88,06%	0,87%	7,35%	0,01%	0,01%	3,71%	87,16%	1,81%	8,17%	0,01%	0,01%	2,84%
SE	75,21%	2,53%	11,59%	0,00%	0,04%	10,63%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
SI	81,06%	2,09%	8,51%	0,00%	0,04%	8,30%	84,26%	1,23%	9,28%	0,00%	0,05%	5,18%
SK	80,31%	1,76%	11,95%	0,00%	0,02%	5,95%	83,27%	1,52%	11,63%	0,00%	0,02%	3,55%
GB	76,63%	2,71%	9,52%	0,00%	0,04%	11,10%	79,66%	2,34%	8,85%	0,00%	0,04%	9,11%
NO	79,41%	2,39%	9,19%	0,01%	0,05%	8,95%	82,02%	1,97%	9,04%	0,00%	0,03%	6,93%

Table S22: Relative contribution of impact category to total impact according to ReCiPe for 2005 and 2010. The values sum per country and year up to 100%. Shading indicates the magnitude of contribution in comparison across the countries, i.e. the darker the shade, the higher this country's relative contribution for the selected impact category. No data was available for Ireland and Sweden in 2005.

ReCiPe

	2010					2005				
	Glob. warm.	Terr. acid.	Toxicity	Water stress	Land occ.	Glob. warm.	Terr. acid.	Toxicity	Water stress	Land occ.
AT	15,82%	9,15%	0,29%	1,53%	73,21%	15,45%	7,74%	0,25%	1,47%	75,09%
BE	14,44%	10,33%	0,30%	2,76%	72,16%	13,93%	8,99%	0,26%	2,58%	74,24%
BG	17,60%	19,74%	0,20%	0,91%	61,55%	13,99%	22,67%	0,24%	0,61%	62,51%
CY	16,93%	16,82%	2,56%	2,64%	61,04%	14,41%	13,47%	1,20%	2,27%	68,65%
CZ	24,94%	12,21%	0,20%	1,42%	61,22%	24,26%	11,07%	0,19%	1,33%	63,16%
DE	18,37%	10,54%	0,52%	2,14%	68,42%	17,56%	9,36%	0,48%	1,94%	70,66%
DK	15,16%	13,75%	1,27%	1,55%	68,28%	14,03%	11,77%	1,04%	1,31%	71,85%
EE	15,91%	9,74%	0,28%	0,73%	73,35%	12,48%	7,90%	0,30%	0,49%	78,83%
ES	11,51%	7,42%	0,21%	3,44%	77,42%	11,67%	8,48%	0,19%	2,72%	76,96%
FI	11,37%	5,39%	0,26%	0,75%	82,23%	8,70%	4,37%	0,23%	0,67%	86,04%
FR	13,07%	9,65%	0,22%	1,74%	75,32%	12,37%	8,73%	0,24%	1,79%	76,88%
GR	17,35%	17,30%	2,32%	2,95%	60,07%	14,74%	22,33%	2,07%	2,82%	58,04%
HR	8,45%	5,55%	0,19%	0,85%	84,97%	9,07%	6,15%	0,19%	0,76%	83,83%
HU	17,09%	8,40%	0,17%	1,19%	73,16%	17,94%	8,60%	0,19%	1,09%	72,19%
IE	16,38%	10,28%	0,28%	1,73%	71,33%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
IT	15,15%	9,38%	0,41%	2,53%	72,52%	18,95%	8,71%	0,58%	1,07%	70,69%
LT	9,68%	6,10%	0,15%	0,73%	83,33%	9,45%	6,37%	0,17%	0,73%	83,28%
LU	11,40%	7,83%	0,29%	3,59%	76,89%	10,47%	6,61%	0,19%	3,35%	79,38%
LV	10,00%	7,72%	0,19%	0,60%	81,49%	6,87%	4,62%	0,23%	0,56%	87,72%
MT	21,00%	12,28%	0,47%	1,95%	64,29%	19,81%	12,75%	0,49%	1,93%	65,02%
NL	15,15%	9,14%	0,25%	2,48%	72,98%	12,95%	7,44%	0,23%	2,01%	77,37%
PL	22,88%	12,54%	0,17%	1,64%	62,78%	22,26%	13,86%	0,14%	1,39%	62,35%
PT	12,05%	7,21%	0,20%	2,73%	77,80%	12,73%	6,98%	0,22%	2,17%	77,90%
RO	9,78%	8,48%	0,11%	0,99%	80,63%	11,94%	10,79%	0,10%	1,26%	75,91%
SE	9,98%	6,59%	0,30%	1,12%	82,01%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
SI	12,78%	8,33%	0,18%	1,42%	77,30%	14,49%	9,79%	0,22%	1,12%	74,38%
SK	21,12%	9,71%	0,24%	2,04%	66,89%	20,44%	8,87%	0,34%	1,92%	68,43%
GB	18,65%	11,03%	0,46%	2,03%	67,83%	17,45%	10,08%	0,36%	1,80%	70,31%
NO	7,82%	6,86%	0,73%	1,18%	83,41%	6,88%	5,45%	0,54%	1,12%	86,01%

Table S23: LC-Impact biodiversity losses embodied in trade. The table gives the biodiversity losses [PDF.yr] sourced domestically, exported, and imported, as well as the negative net trade (= import – export) for all European countries in 2005 and 2010. The colour-coding denotes the highest losses per category across countries (green – low; red – high). Average and total losses are given at the bottom of the table. A red zero marks data unavailability.

	2010				**2005**			
	Domestic	**Export**	**Import**	**Negative net-trade**	**Domestic**	**Export**	**Import**	**Negative net-trade**
AT	5,32E-06	3,18E-06	1,61E-05	1,29E-05	5,94E-06	2,06E-06	1,66E-05	1,45E-05
BE	1,14E-06	1,00E-06	3,60E-05	3,50E-05	1,27E-06	8,30E-07	3,94E-05	3,86E-05
BG	4,77E-06	2,47E-06	3,73E-06	1,26E-06	6,75E-06	1,31E-06	4,30E-06	2,99E-06
CY	1,61E-06	5,09E-07	2,35E-06	1,85E-06	1,44E-06	7,14E-07	2,47E-06	1,75E-06
CZ	3,29E-06	1,49E-06	9,73E-06	8,24E-06	3,39E-06	1,48E-06	8,57E-06	7,09E-06
DE	1,40E-05	3,99E-06	1,76E-04	1,72E-04	1,49E-05	3,15E-06	1,93E-04	1,90E-04
DK	1,67E-06	1,04E-06	1,03E-05	9,30E-06	1,85E-06	7,46E-07	1,27E-05	1,19E-05
EE	3,00E-07	1,72E-07	1,61E-06	1,44E-06	3,95E-07	1,11E-07	1,32E-06	1,21E-06
ES	1,30E-04	4,59E-05	8,70E-05	4,10E-05	1,44E-04	3,47E-05	1,18E-04	8,36E-05
FI	9,97E-07	2,96E-07	8,77E-06	8,48E-06	8,78E-07	2,65E-07	1,00E-05	9,74E-06
FR	5,58E-05	1,93E-05	1,13E-04	9,36E-05	5,60E-05	1,74E-05	1,41E-04	1,23E-04
GR	4,05E-05	1,01E-05	1,97E-05	9,68E-06	3,90E-05	5,42E-06	2,35E-05	1,81E-05
HR	5,86E-06	6,65E-07	3,89E-06	3,22E-06	4,89E-06	6,81E-07	4,85E-06	4,17E-06
HU	2,30E-06	2,10E-06	5,77E-06	3,67E-06	3,03E-06	1,28E-06	7,04E-06	5,75E-06
IE	5,82E-07	1,08E-06	9,30E-06	8,22E-06	0	7,91E-07	0	-7,91E-07
IT	1,06E-04	1,60E-05	1,40E-04	1,24E-04	3,01E-05	1,41E-05	8,75E-05	7,34E-05
LT	1,03E-06	4,51E-07	2,94E-06	2,49E-06	1,21E-06	2,57E-07	2,37E-06	2,12E-06
LU	2,53E-08	7,15E-08	3,26E-06	3,19E-06	2,46E-08	5,34E-08	3,57E-06	3,51E-06
LV	3,01E-07	3,39E-07	1,43E-06	1,09E-06	4,55E-07	1,72E-07	1,27E-06	1,10E-06
MT	7,08E-08	2,07E-08	8,44E-07	8,23E-07	0	1,62E-08	0	-1,62E-08
NL	1,37E-06	1,47E-06	6,38E-05	6,23E-05	0	1,54E-06	0	-1,54E-06
PL	1,65E-05	3,49E-06	2,51E-05	2,16E-05	1,83E-05	2,82E-06	2,18E-05	1,90E-05
PT	1,80E-05	5,72E-06	2,84E-05	2,27E-05	1,92E-05	5,98E-06	3,03E-05	2,44E-05
RO	0	4,02E-06	0	-4,02E-06	0	2,60E-06	0	-2,60E-06
SE	1,15E-06	6,25E-07	1,68E-05	1,62E-05	0	6,02E-07	0	-6,02E-07
SI	1,20E-06	3,40E-07	3,87E-06	3,53E-06	1,13E-06	3,11E-07	3,57E-06	3,26E-06
SK	2,75E-06	2,04E-06	5,06E-06	3,02E-06	3,23E-06	1,31E-06	4,20E-06	2,89E-06
GB	8,53E-06	2,35E-06	1,46E-04	1,43E-04	1,08E-05	1,84E-06	2,14E-04	2,13E-04
NO	9,25E-07	1,53E-06	1,68E-05	1,53E-05	1,33E-06	1,65E-06	2,11E-05	1,94E-05
Average	1,52E-05	4,54E-06	3,42E-05	2,85E-05	1,54E-05	3,59E-06	4,05E-05	3,00E-05
Sum	4,27E-04	1,32E-04	9,58E-04	8,26E-04	3,70E-04	1,04E-04	9,73E-04	8,69E-04

Table S24: Share of LC-Impact biodiversity footprints embodied in trade. The table shows the import shares (imp.) and the share of domestically caused biodiversity losses (dom.) for both reference years. The table is sorted by the GDP per capita in 2010. Mind that shares equal to 100% or 0% denote that for this country no data was available; more specifically, the shares were calculated using the footprint disaggregation by degree of urbanisation, the contributions of which were thereafter put together. Hence, results on, for instance, Sweden in 2005 are missing.

Country	2010		2005		2005 - 2010 Differ-ence	GDP 2010 [M.EUR]	Popula-tion 2010	GDP per capita 2010 [M.EUR]
	Imp.	Dom.	Imp.	Dom.				
LU	99,23%	0,77%	99,32%	0,68%	0,08%	3,95E+04	5,07E+05	7,79E-02
NO	94,79%	5,21%	94,06%	5,94%	-0,74%	3,23E+05	4,89E+06	6,61E-02
DK	86,11%	13,89%	87,25%	12,75%	1,14%	2,41E+05	5,55E+06	4,35E-02
SE	93,58%	6,42%	100,00%	0,00%	6,42%	3,68E+05	9,38E+06	3,93E-02
NL	97,89%	2,11%	100,00%	0,00%	2,11%	6,31E+05	1,66E+07	3,80E-02
IE	94,11%	5,89%	100,00%	0,00%	5,89%	1,66E+05	4,56E+06	3,64E-02
AT	75,12%	24,88%	73,64%	26,36%	-1,47%	2,94E+05	8,39E+06	3,51E-02
FI	89,79%	10,21%	91,94%	8,06%	2,15%	1,87E+05	5,36E+06	3,49E-02
BE	96,93%	3,07%	96,88%	3,12%	-0,06%	3,65E+05	1,09E+07	3,34E-02
DE	92,64%	7,36%	92,83%	7,17%	0,19%	2,58E+06	8,18E+07	3,15E-02
FR	66,92%	33,08%	71,54%	28,46%	4,62%	2,00E+06	6,50E+07	3,07E-02
GB	94,47%	5,53%	95,21%	4,79%	0,74%	1,81E+06	6,28E+07	2,89E-02
IT	56,82%	43,18%	74,43%	25,57%	17,61%	1,60E+06	5,93E+07	2,71E-02
ES	40,01%	59,99%	45,08%	54,92%	5,08%	1,08E+06	4,66E+07	2,32E-02
GR	32,75%	67,25%	37,59%	62,41%	4,85%	2,26E+05	1,12E+07	2,02E-02
SI	76,40%	23,60%	75,91%	24,09%	-0,49%	3,62E+04	2,05E+06	1,77E-02
CY	59,43%	40,57%	63,18%	36,82%	3,75%	1,91E+04	1,10E+06	1,73E-02
PT	61,27%	38,73%	61,23%	38,77%	-0,04%	1,80E+05	1,06E+07	1,70E-02
MT	92,26%	7,74%	100,00%	0,00%	7,74%	6,59E+03	4,15E+05	1,59E-02
CZ	74,73%	25,27%	71,67%	28,33%	-3,05%	1,56E+05	1,05E+07	1,49E-02
SK	64,78%	35,22%	56,52%	43,48%	-8,26%	6,73E+04	5,39E+06	1,25E-02
EE	84,29%	15,71%	77,01%	22,99%	-7,28%	1,47E+04	1,33E+06	1,11E-02
HR	39,87%	60,13%	49,77%	50,23%	9,90%	4,50E+04	4,42E+06	1,02E-02
HU	71,48%	28,52%	69,93%	30,07%	-1,55%	9,81E+04	1,00E+07	9,81E-03
PL	60,26%	39,74%	54,37%	45,63%	-5,89%	3,62E+05	3,82E+07	9,47E-03
LT	73,98%	26,02%	66,27%	33,73%	-7,71%	2,80E+04	3,10E+06	9,04E-03
LV	82,56%	17,44%	73,61%	26,39%	-8,95%	1,79E+04	2,10E+06	8,54E-03
RO	100,00%	0,00%	100,00%	0,00%	0,00%	1,27E+05	2,02E+07	6,26E-03
BG	43,88%	56,12%	38,92%	61,08%	-4,97%	3,77E+04	7,40E+06	5,09E-03
Total	69,17%	30,83%	72,47%	27,53%	3,30%	1,31E+07	5,10E+08	

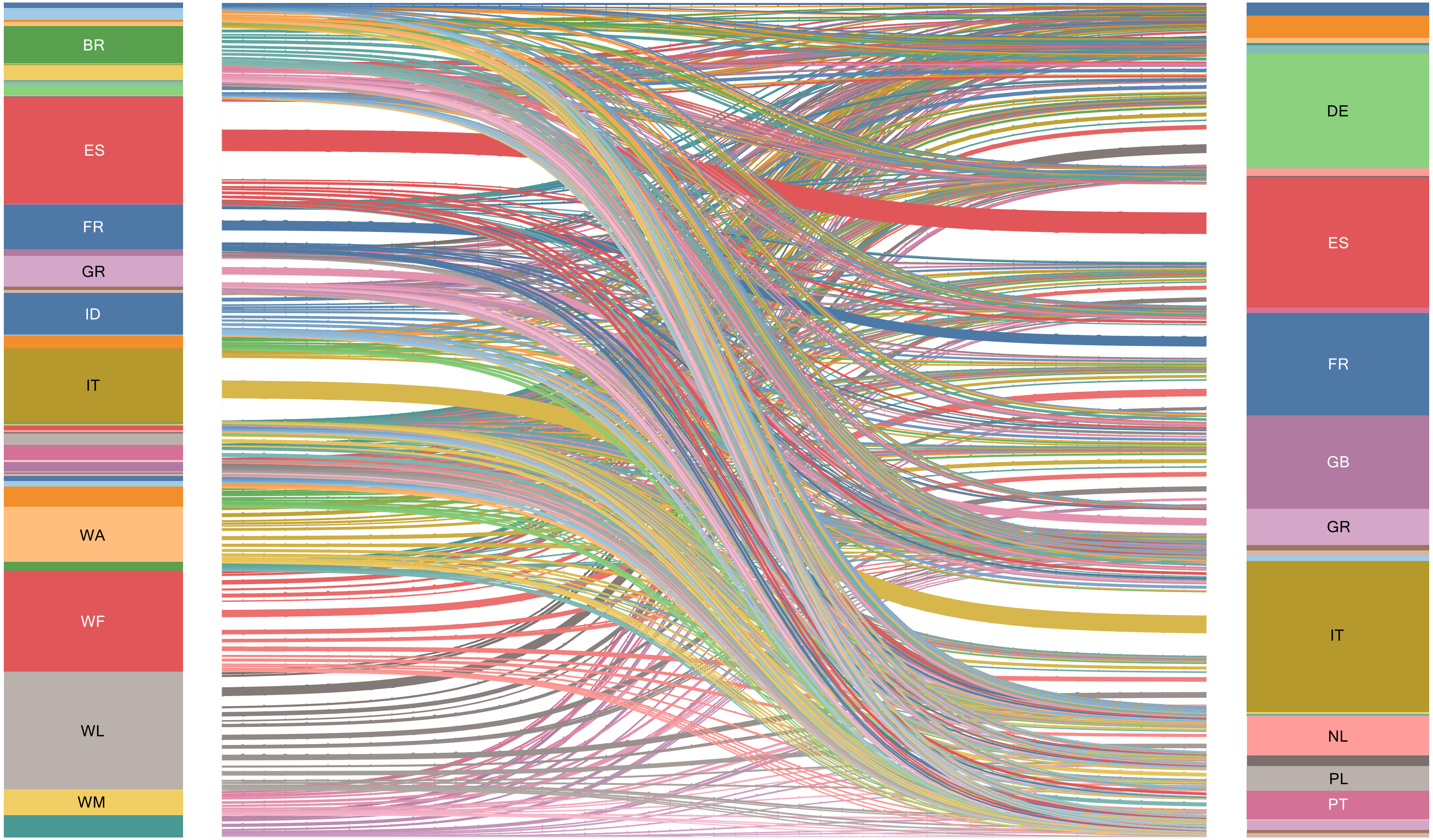

Figure S9: Flow chart of absolute LC-Impact biodiversity footprints embodied in trade in 2010. For a detailed overview please see the attached Tableau file. For a reduced overview, please see the following figure. The origin of impacts is shown on the left, while the right depicts the destinations of embodied footprints. For the precise values, see the import share sheet in the data analysis Excel workbook for 2010.

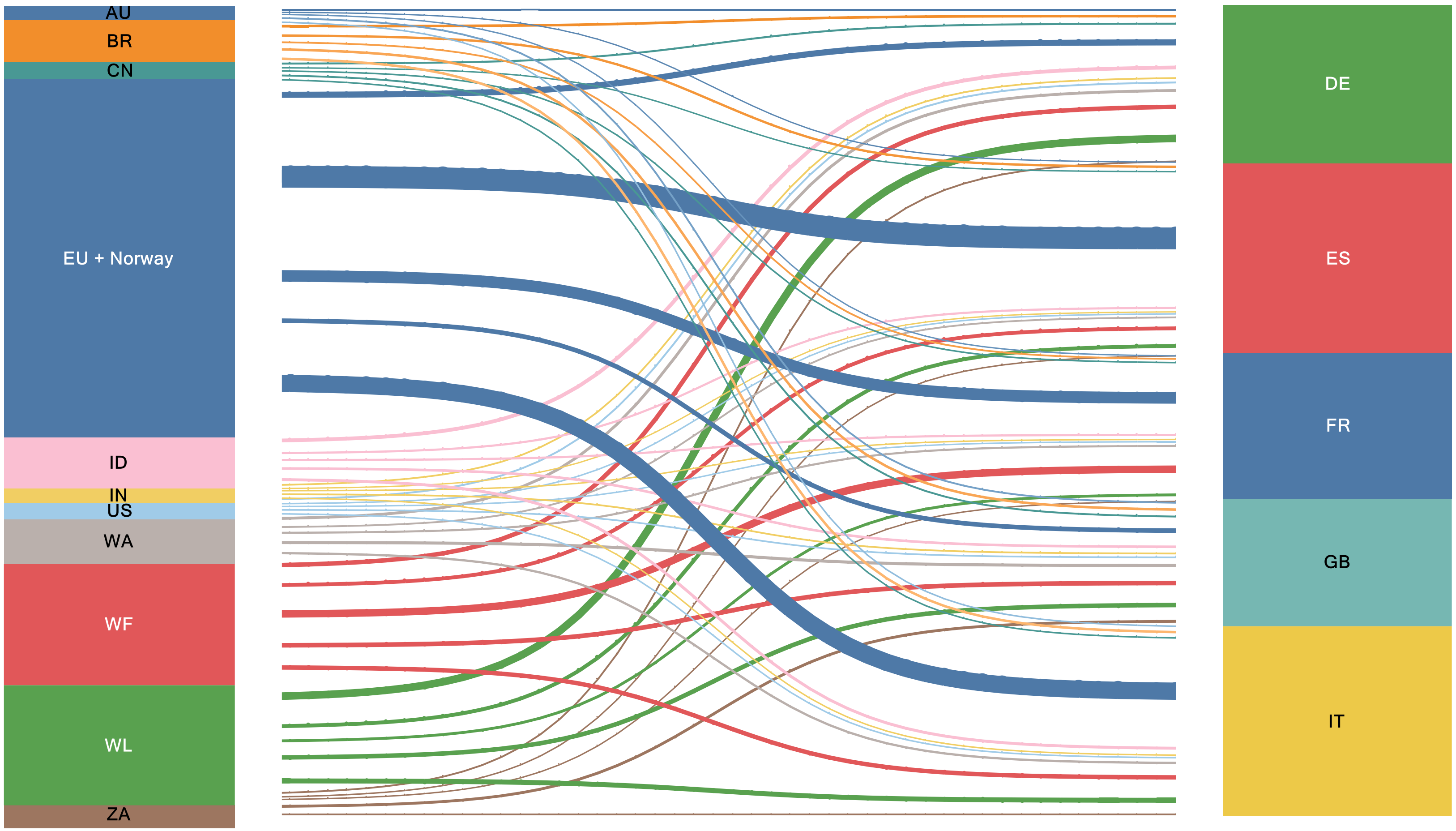

Figure S10: Reduced flow chart of absolute LC-Impact biodiversity footprints embodied in trade in 2010. The origin of impacts is shown on the left, while the right depicts the destinations of embodied footprints. The chart only shows the origins whose share of total origin is above 1.5% of all Exiobase regions; EU28 countries and Norway are shown as one group "EU + Norway". The destinations only comprise Europe's major economies.

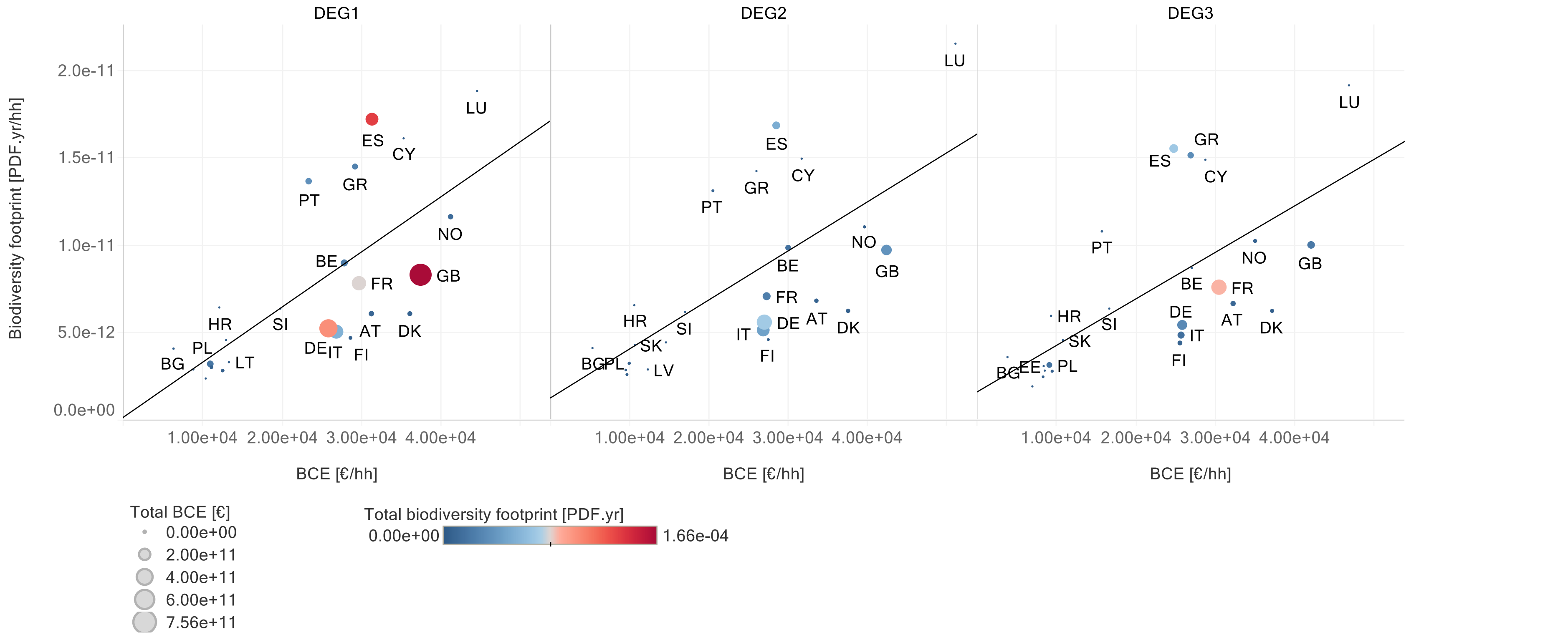

Figure S11: LC-Impact biodiversity footprints disaggregated by degrees of urbanisation for 2005. The axes show the biodiversity footprints and balanced consumer expenditure (BCE) per household; circle sizes indicate the total balanced consumer expenditure (small – low, big – high); colouring denotes the total biodiversity footprint (blue – low, red – high). The dotted lines are linear trend lines.

Table S25: Ranking of national LC-Impact footprints per impact category and degree of urbanisation in absolute terms for 2010.

	DEG1						DEG2						DEG3							
	Land	Water	GWP	POCP	Eutro.	Acid.	Land	Water	GWP	POCP	Eutro.	Acid.	Land	Water	GWP	POCP	Eutro.	Acid.	GDP [M.EUR]	Population
DE	3	1	1	1	1	3	2	1	1	1	1	2	6	3	4	6	3	6	2577577,6	81776930,0
FR	5	5	4	5	5	6	5	6	4	4	5	6	1	1	1	2	1	3	1996558,1	65023142,0
GB	4	2	2	6	2	2	4	3	3	5	3	3	5	4	3	7	4	4	1813065,6	62766365,0
IT	2	3	3	3	3	1	1	2	2	2	2	1	3	5	6	5	5	1	1604149,5	59277417,0
ES	1	4	5	2	4	5	3	4	5	3	4	5	2	2	5	3	2	5	1079873,0	46576897,0
NL	6	6	7	9	6	7	6	5	6	8	6	4	21	22	23	25	20	22	630904,4	16615394,0
SE	16	15	19	19	15	18	12	12	13	16	11	11	9	8	8	8	6	7	368392,3	9378126,0
BE	9	7	9	10	7	8	8	7	7	9	7	8	23	20	25	26	22	23	364749,7	10920272,0
PL	10	9	6	7	9	9	11	10	8	10	12	14	7	6	2	4	7	8	361501,5	38183683,0
NO	11	11	11	11	8	10	13	14	16	12	10	16	11	9	13	12	9	12	323245,9	4889252,0
AT	12	14	14	14	13	13	10	11	10	11	9	9	10	10	9	10	10	9	294344,0	8389771,0
DK	15	17	16	16	16	17	16	16	15	15	16	15	13	12	11	11	12	10	241240,4	5547683,0
GR	7	8	8	4	11	4	9	9	9	6	13	7	4	7	7	1	8	2	225814,0	11153454,0
FI	13	12	10	15	12	11	23	21	18	22	17	18	22	19	16	20	18	19	186920,0	5363352,0
PT	8	10	13	8	10	12	7	8	11	7	8	10	8	13	17	9	11	15	179756,7	10573100,0
IE	17	13	18	20	14	19	15	13	17	19	14	17	16	11	15	19	13	14	165997,6	4560155,0
CZ	14	16	12	17	17	16	14	15	12	13	15	12	14	14	10	13	14	11	156156,3	10474410,0
RO	29	29	29	29	29	29	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	126724,1	20246871,0
HU	20	20	17	18	19	20	19	19	14	17	22	23	17	17	12	15	19	18	98130,2	10000023,0
SK	21	23	21	23	24	24	18	18	20	20	19	22	15	16	14	18	16	17	67322,3	5391428,0
HR	18	24	22	21	18	22	17	23	22	21	20	24	12	21	19	17	15	21	45006,6	4417781,0
LU	24	22	28	28	23	21	22	17	23	24	21	20	27	26	27	27	27	26	39487,5	506953,0
BG	19	21	15	13	20	14	21	22	19	14	23	13	19	23	18	14	23	13	37670,2	7395599,0
SI	25	25	27	27	25	27	20	20	21	23	18	21	18	18	21	22	17	20	36217,5	2048583,0
LT	23	18	20	22	21	25	27	25	27	27	27	27	20	15	20	21	21	24	28008,1	3097282,0
CY	22	19	23	12	22	15	24	24	24	18	24	19	25	24	26	16	26	16	19099,3	1103685,0
LV	28	26	24	24	27	23	28,5	28,5	28,5	28,5	28,5	28,5	26	25	22	23	25	25	17910,1	2097555,0
EE	26	28	25	26	26	28	26	27	25	26	25	26	24	27	24	24	24	27	14713,1	1331475,0
MT	27	27	26	25	28	26	25	26	26	25	26	25	28,5	28,5	28,5	28,5	28,5	28,5	6593,2	414508,0

Table S26: Ranking of national LC-Impact footprints per impact category and degree of urbanisation in per capita terms for 2010.

	DEG1						DEG2						DEG3							
	Land	**Water**	**GWP**	**POCP**	**Eutro.**	**Acid.**	**Land**	**Water**	**GWP**	**POCP**	**Eutro.**	**Acid.**	**Land**	**Water**	**GWP**	**POCP**	**Eutro.**	**Acid.**	**GDP [M.EUR]**	**GDP per cap. [M.EUR]**
LU	1	1	1	8	1	3	1	1	1	6	1	3	3	1	2	9	2	4	39487,5	0,077892
NO	7	2	2	3	2	6	7	4	4	4	2	7	7	4	4	4	1	8	323245,9	0,066114
DK	17	17	9	7	16	9	16	14	7	8	16	8	16	15	7	7	18	9	241240,4	0,043485
SE	19	13	18	20	12	15	18	13	14	18	11	14	17	13	12	17	11	11	368392,3	0,039282
NL	6	5	7	19	3	5	6	5	10	21	3	5	8	8	10	20	5	7	630904,4	0,037971
IE	15	6	8	17	5	11	17	7	11	19	9	13	18	7	9	19	10	14	165997,6	0,036402
AT	11	16	11	11	11	12	11	16	8	9	12	11	13	18	11	11	15	12	294344,0	0,035084
FI	21	19	6	16	13	17	20	19	2	13	14	16	19	19	1	14	13	16	186920,0	0,034851
BE	8	3	10	18	4	7	8	2	9	16	4	6	6	2	6	13	3	5	364749,7	0,033401
DE	14	8	16	10	6	14	15	8	16	11	6	12	15	10	14	10	7	10	2577577,6	0,031520
FR	12	20	23	12	17	19	10	20	19	12	17	19	9	17	17	8	12	18	1996558,1	0,030705
GB	16	10	14	21	8	10	14	9	12	20	5	10	10	5	5	12	4	6	1813065,6	0,028886
IT	5	12	13	6	9	4	5	11	15	7	7	4	5	11	13	6	6	3	1604149,5	0,027062
ES	2	9	24	5	10	18	3	10	22	5	10	18	2	9	21	5	9	17	1079873,0	0,023185
GR	4	7	3	2	18	2	2	6	3	2	18	2	1	6	3	1	16	1	225814,0	0,020246
SI	10	11	12	15	7	13	12	12	17	15	8	15	12	12	16	16	8	13	36217,5	0,017679
CY	9	4	5	1	15	1	9	3	5	1	13	1	11	3	8	2	14	2	19099,3	0,017305
PT	3	14	27	4	14	20	4	15	23	3	15	20	4	16	23	3	17	20	179756,7	0,017001
MT	18	18	4	9	21	8	19	18	6	10	21	9	28,5	28,5	28,5	28,5	28,5	28,5	6593,2	0,015906
CZ	24	22	17	27	25	21	24	22	18	24	24	21	23	21	18	23	23	19	156156,3	0,014908
SK	20	21	20	26	22	24	21	21	21	25	22	23	20	20	20	24	22	23	67322,3	0,012487
EE	22	24	15	23	19	25	22	23	13	22	19	24	21	22	15	21	19	24	14713,1	0,011050
HR	13	25	28	14	20	23	13	25	25	14	20	22	14	24	26	18	20	22	45006,6	0,010188
HU	27	27	25	28	27	28	27	26	26	27	26	27	26	27	27	27	27	27	98130,2	0,009813
PL	25	23	19	22	26	27	25	24	20	23	25	26	25	23	19	22	25	26	361501,5	0,009467
LT	23	15	21	25	23	26	23	17	24	26	23	25	22	14	22	25	21	25	28008,1	0,009043
LV	28	26	22	24	24	22	28,5	28,5	28,5	28,5	28,5	28,5	27	25	25	26	24	21	17910,1	0,008539
RO	29	29	29	29	29	29	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	28,5	126724,1	0,006259
BG	26	28	26	13	28	16	26	27	27	17	27	17	24	26	24	15	26	15	37670,2	0,005094

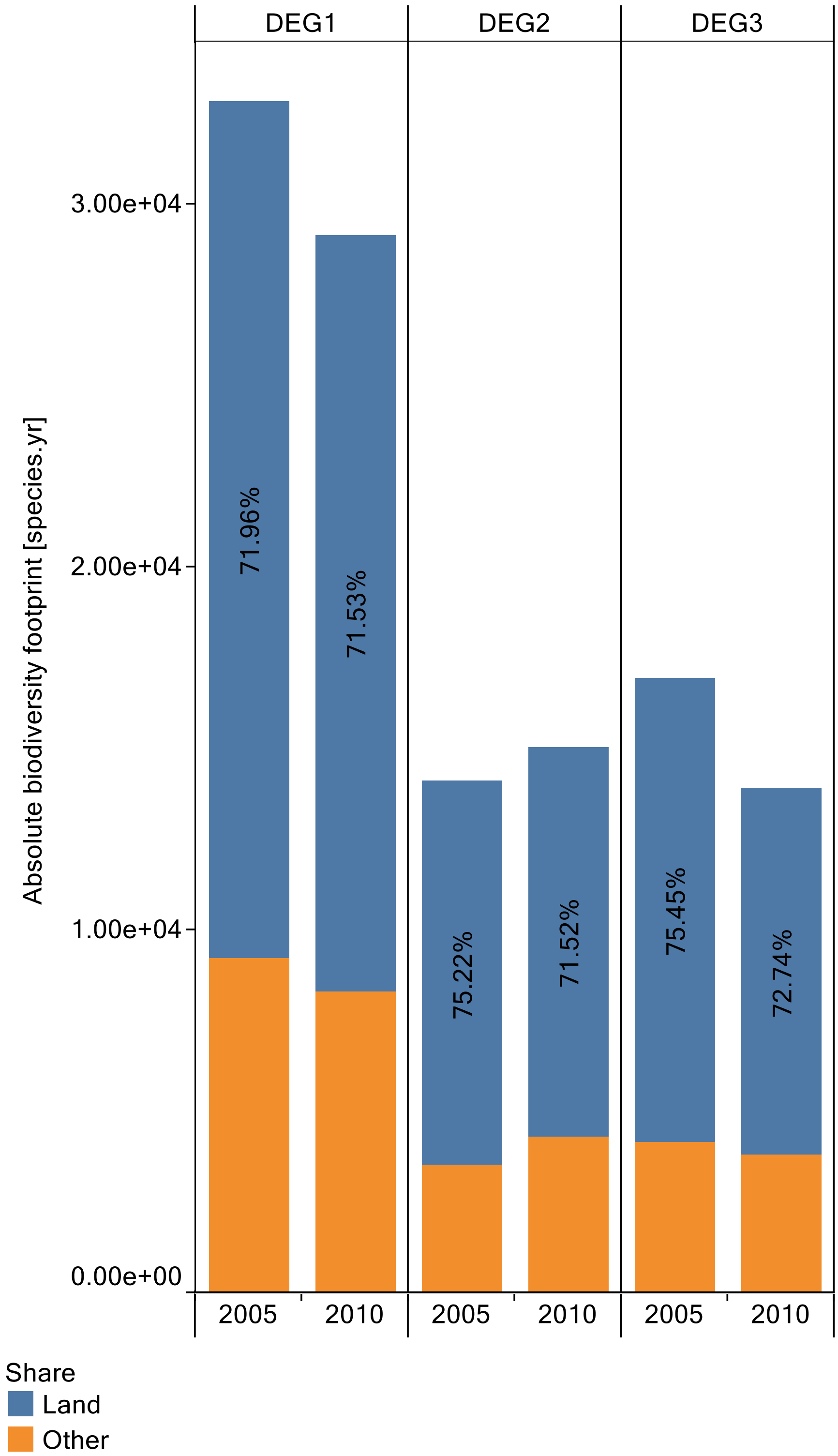

Figure S12: Differences across urbanisation degrees and the importance of land use. DEG1 = cities, DEG2 = towns, DEG3 = rural. For Ireland, Malta, the Netherlands, and Sweden, no 2005 data was available; therefore, 2010 data was used for these countries. Romania is not included due to a lack of data in both years. "Other" includes global warming, water stress, terrestrial acidification, and toxicity.

Table S27: Absolute LC-Impact biodiversity footprints per degree of urbanisation for 2005 and 2010. Totals per degree of urbanisation are displayed in the bottom row; sums across the degrees of urbanisation per impact category are shown in the column "Sum". The unit is [PDF.yr].

	2010				**2005**			
Impact category	**DEG1**	**DEG2**	**DEG3**	**Sum**	**DEG1**	**DEG2**	**DEG3**	**Sum**
Land occ.	5,76E-04	3,06E-04	2,45E-04	1,13E-03	5,84E-04	2,43E-04	2,79E-04	1,11E-03
Water stress	1,37E-05	7,34E-06	5,29E-06	2,64E-05	1,46E-05	6,22E-06	6,54E-06	2,73E-05
CO2	1,40E-05	7,24E-06	6,35E-06	2,76E-05	1,47E-05	6,27E-06	6,76E-06	2,77E-05
CH4	2,18E-06	1,12E-06	9,82E-07	4,28E-06	2,02E-06	8,37E-07	1,01E-06	3,87E-06
CH4 fossil	1,75E-06	9,81E-07	8,35E-07	3,56E-06	2,00E-06	9,44E-07	9,27E-07	3,88E-06
N2O	1,04E-06	5,43E-07	4,92E-07	2,08E-06	9,62E-07	4,01E-07	4,90E-07	1,85E-06
SF6	4,85E-08	2,73E-08	1,91E-08	9,49E-08	4,15E-08	2,08E-08	1,90E-08	8,12E-08
NMVOC	3,25E-05	1,75E-05	1,49E-05	6,49E-05	3,58E-05	1,59E-05	1,67E-05	6,83E-05
POCP	3,49E-08	1,74E-08	1,61E-08	6,83E-08	3,90E-08	1,55E-08	2,07E-08	7,51E-08
FW Eutroph.	2,01E-07	1,08E-07	7,51E-08	3,84E-07	2,03E-07	8,71E-08	8,66E-08	3,76E-07
Terr. acid.	6,70E-05	3,67E-05	2,45E-05	1,28E-04	5,47E-05	2,32E-05	2,48E-05	1,03E-04
TOTAL	7,08E-04	3,77E-04	2,99E-04	1,38E-03	7,09E-04	2,97E-04	3,36E-04	1,34E-03

Table S28: Per capita LC-Impact biodiversity footprints per degree of urbanisation for 2005 and 2010. Totals per degree of urbanisation are displayed in the bottom row; column "Average" contains the European per capita average per impact category. The unit is [PDF.yr/cap.].

	2010				**2005**			
Impact category	**DEG1**	**DEG2**	**DEG3**	**Average**	**DEG1**	**DEG2**	**DEG3**	**Average**
Land occ.	2,42E-12	2,34E-12	2,03E-12	2,30E-12	2,65E-12	2,26E-12	2,29E-12	2,46E-12
Water stress	5,77E-14	5,63E-14	4,38E-14	5,39E-14	6,61E-14	5,79E-14	5,38E-14	6,08E-14
CO2	5,86E-14	5,55E-14	5,26E-14	5,63E-14	6,64E-14	5,83E-14	5,56E-14	6,15E-14
CH4	9,15E-15	8,57E-15	8,13E-15	8,74E-15	9,17E-15	7,78E-15	8,28E-15	8,60E-15
CH4 fossil	7,34E-15	7,52E-15	6,92E-15	7,28E-15	9,09E-15	8,78E-15	7,63E-15	8,62E-15
N2O	4,38E-15	4,17E-15	4,08E-15	4,25E-15	4,36E-15	3,73E-15	4,04E-15	4,12E-15
SF6	2,04E-16	2,09E-16	1,58E-16	1,94E-16	1,88E-16	1,93E-16	1,56E-16	1,81E-16
NMVOC	1,36E-13	1,34E-13	1,23E-13	1,33E-13	1,62E-13	1,48E-13	1,37E-13	1,52E-13
POCP	1,46E-16	1,34E-16	1,33E-16	1,40E-16	1,77E-16	1,44E-16	1,71E-16	1,67E-16
FW Eutroph.	8,44E-16	8,25E-16	6,22E-16	7,84E-16	9,19E-16	8,10E-16	7,13E-16	8,37E-16
Terr. acid.	2,81E-13	2,82E-13	2,03E-13	2,62E-13	2,48E-13	2,16E-13	2,04E-13	2,28E-13
TOTAL	2,97E-12	2,89E-12	2,48E-12	2,83E-12	3,22E-12	2,76E-12	2,77E-12	2,99E-12

Table S29: Relative contribution of LC-Impact biodiversity footprints per degree of urbanisation in 2005 and 2010. While the percentages of absolute footprints were derived by dividing the footprint per impact category and degree by the impact sum across the degrees (

Table S27*), the percentages of per capita footprints were derived by dividing the footprint per impact category and degree by the European average per impact category since the sum across urbanisation degrees would be incorrect on the per capita level (Table S28).*

	Absolute						**Per capita**					
	2010			**2005**			**2010**			**2005**		
Impact category	**DEG1**	**DEG2**	**DEG3**	**DEG1**	**DEG2**	**DEG3**	**DEG1**	**DEG2**	**DEG3**	**DEG1**	**DEG2**	**DEG3**
Land occ.	51,10%	27,12%	21,78%	52,83%	21,96%	25,21%	104,97%	101,75%	88,30%	107,69%	91,81%	93,29%
Water stress	52,12%	27,83%	20,05%	53,34%	22,76%	23,91%	107,07%	104,43%	81,27%	108,71%	95,13%	88,49%
CO2	50,67%	26,27%	23,06%	52,93%	22,66%	24,41%	104,08%	98,58%	93,48%	107,89%	94,73%	90,34%
CH4	50,95%	26,11%	22,94%	52,33%	21,65%	26,02%	104,66%	97,97%	93,00%	106,66%	90,50%	96,32%
CH4 fossil	49,05%	27,53%	23,42%	51,73%	24,36%	23,91%	100,76%	103,30%	94,95%	105,44%	101,84%	88,50%
N2O	50,17%	26,15%	23,68%	51,90%	21,64%	26,45%	103,05%	98,13%	96,01%	105,79%	90,47%	97,91%
SF6	51,12%	28,79%	20,08%	51,08%	25,55%	23,37%	105,01%	108,05%	81,42%	104,12%	106,80%	86,51%
NMVOC	50,07%	27,00%	22,93%	52,35%	23,23%	24,42%	102,86%	101,31%	92,95%	106,70%	97,11%	90,38%
POCP	51,01%	25,47%	23,52%	51,85%	20,57%	27,58%	104,78%	95,58%	95,35%	105,68%	85,98%	102,09%
FW Eutroph.	52,39%	28,03%	19,58%	53,85%	23,15%	23,00%	107,61%	105,20%	79,37%	109,77%	96,77%	85,12%
Terr. acid.	52,25%	28,64%	19,11%	53,27%	22,60%	24,13%	107,33%	107,48%	77,45%	108,58%	94,49%	89,30%
TOTAL	51,16%	27,24%	21,59%	52,85%	22,11%	25,04%	105,10%	102,24%	87,52%	107,72%	92,44%	92,68%

Table S30: Absolute and relative contribution of LC-Impact biodiversity footprints per type of household in 2010. The derivation of the percentage values is equal to the procedure in Table S29. See Excel file for details.

	Absolute						**Per capita**					
Impact category	**A1**	**A1_DCH**	**A2**	**A2_DCH**	**A_GE3**	**A_GE3_DCH**	**A1**	**A1_DCH**	**A2**	**A2_DCH**	**A_GE3**	**A_GE3_DCH**
Land occ.	16,93%	3,62%	29,20%	30,89%	12,19%	7,17%	129,88%	74,93%	120,00%	84,50%	106,83%	72,90%
Water stress	17,83%	3,89%	30,56%	30,24%	10,93%	6,55%	136,78%	80,54%	125,58%	82,73%	95,77%	66,59%
CO2	18,79%	3,74%	30,11%	29,63%	10,59%	7,14%	144,17%	77,45%	123,72%	81,05%	92,83%	72,56%
CH4	17,69%	4,03%	29,59%	30,94%	10,55%	7,19%	135,74%	83,43%	121,60%	84,64%	92,49%	73,14%
CH4 fossil	18,16%	3,62%	29,46%	30,32%	11,28%	7,15%	139,32%	75,05%	121,07%	82,94%	98,89%	72,71%
N2O	17,55%	3,97%	29,98%	30,70%	10,52%	7,28%	134,65%	82,12%	123,22%	83,98%	92,18%	74,02%
SF6	19,68%	3,83%	31,70%	29,72%	9,42%	5,65%	150,96%	79,34%	130,27%	81,30%	82,53%	57,48%
NMVOC	18,01%	3,67%	29,96%	30,64%	10,78%	6,93%	138,18%	76,02%	123,13%	83,83%	94,49%	70,42%
POCP	16,87%	3,39%	28,49%	31,52%	12,46%	7,27%	129,42%	70,16%	117,08%	86,24%	109,20%	73,88%
FW Eutroph.	17,98%	4,10%	29,99%	30,95%	10,42%	6,57%	137,94%	84,82%	123,25%	84,66%	91,27%	66,80%
Terr. acid.	17,88%	3,70%	28,77%	30,91%	11,95%	6,80%	137,18%	76,56%	118,21%	84,56%	104,69%	69,12%
TOTAL	17,13%	3,64%	29,24%	30,84%	12,04%	7,11%	131,41%	75,33%	120,17%	84,37%	105,47%	72,32%

The following figures (S13 – S15) are based on a sector grouping via a concordance matrix from Ivanova et al. (2017). That is, footprints per each of the 200 EXIOBASE sectors were bridged to 15 sector groups. Figure 4 in the main text leaves out the group "No household demand", because the focus of the study is the household demand. The actual matrix can be found in the digital SI. The names of the sector groups were abbreviated to fit the graphs onto one page each (Table S31).

Table S31: Sector group names

Original sector group name	Abbreviated sector group name
Food: Plant-based	Food plant
Food: Animal-based	Food animal
Food nec	Food nec
Clothing	Clothing
Mobility: Purchase of personal vehicles and private transport equipment	Mobility private transp.
Mobility: Transport fuels	Mobility transp. fuels
Mobility: Transport services	Mobility transp. services
Services	Services
Manufactured products: Appliances, machinery and electronics	Manuf. A&M&E
Manufactured products and shelter: Furniture, household commodities manufactured products nec	Manuf. Hh
Shelter: Actual and imputed rent	Shelter rent
Shelter: Electricity and fuels	Shelter E&F
Shelter: Construction materials and minerals	Shelter construction
Shelter: Waste treatment	Shelter waste
No household demand	No hh demand

The below figures (S13 – S15) show biodiversity footprints disaggregated by socio-economic variables per sectoral contribution, according to both LC-Impact and ReCiPe methodologies in 2010. The figures contain graphs for absolute footprints, but also for per household ones. For the latter it must be noted, that these were derived by dividing the absolute values by the number of households per socio-economic parameter; therefore, the individual and cumulative per household footprints for each sector group across the various socio-economic variables are not equal.

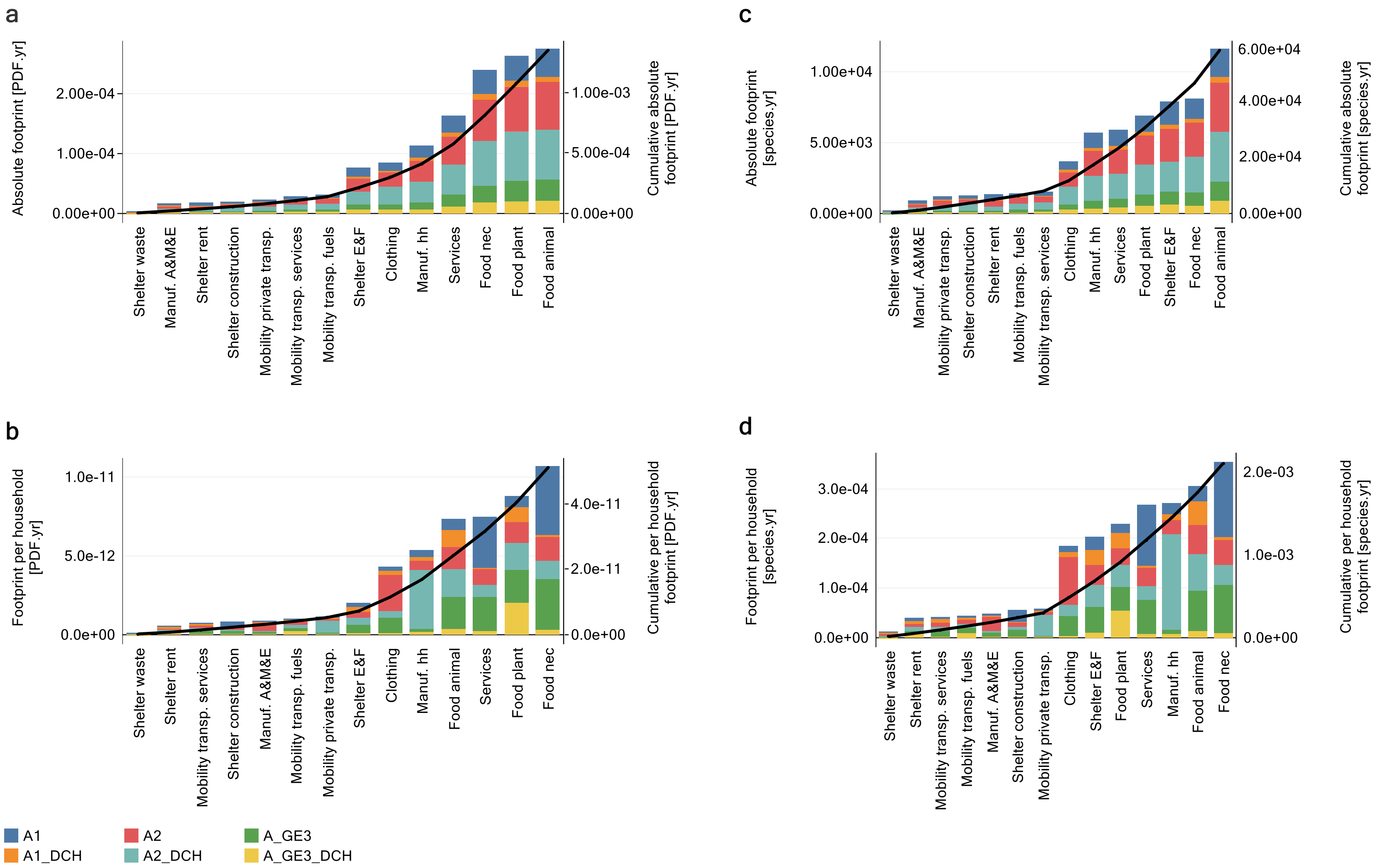

Figure S13: Biodiversity footprints according to LC-Impact and ReCiPe per type of household in 2010. a) and c) show LC-Impact footprints; b) and d) show ReCiPe footprints. a) and c) are in absolute terms, whereas b) and d) are the footprints per type of household per household. The Netherlands is not included due to data availability.

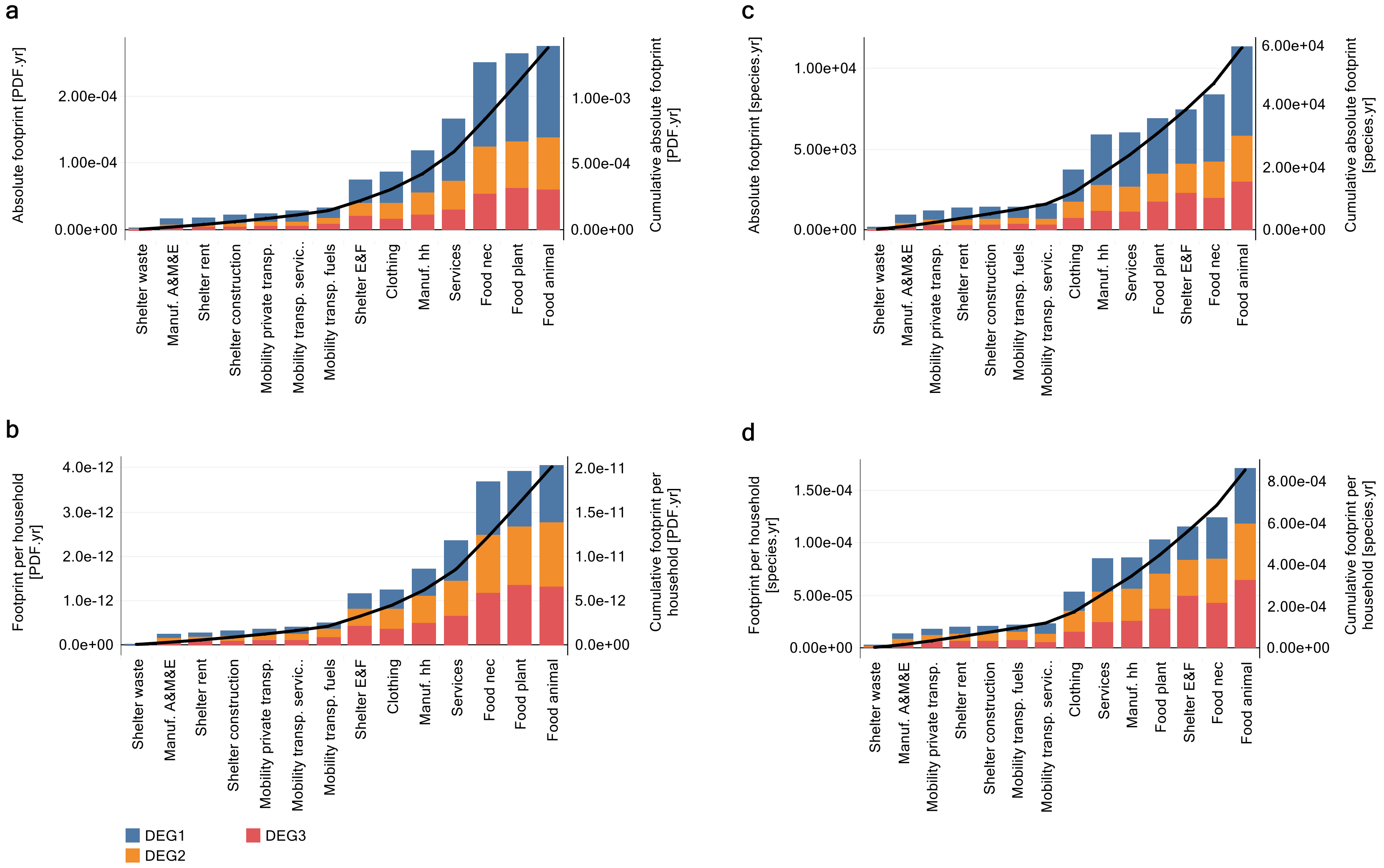

Figure S14: Biodiversity footprints according to LC-Impact and ReCiPe per degree of urbanisation in 2010. a) and c) show LC-Impact footprints; b) and d) show ReCiPe footprints. a) and c) are in absolute terms, whereas b) and d) are the footprints per degree of urbanisation per household. Romania is not included due to data availability.

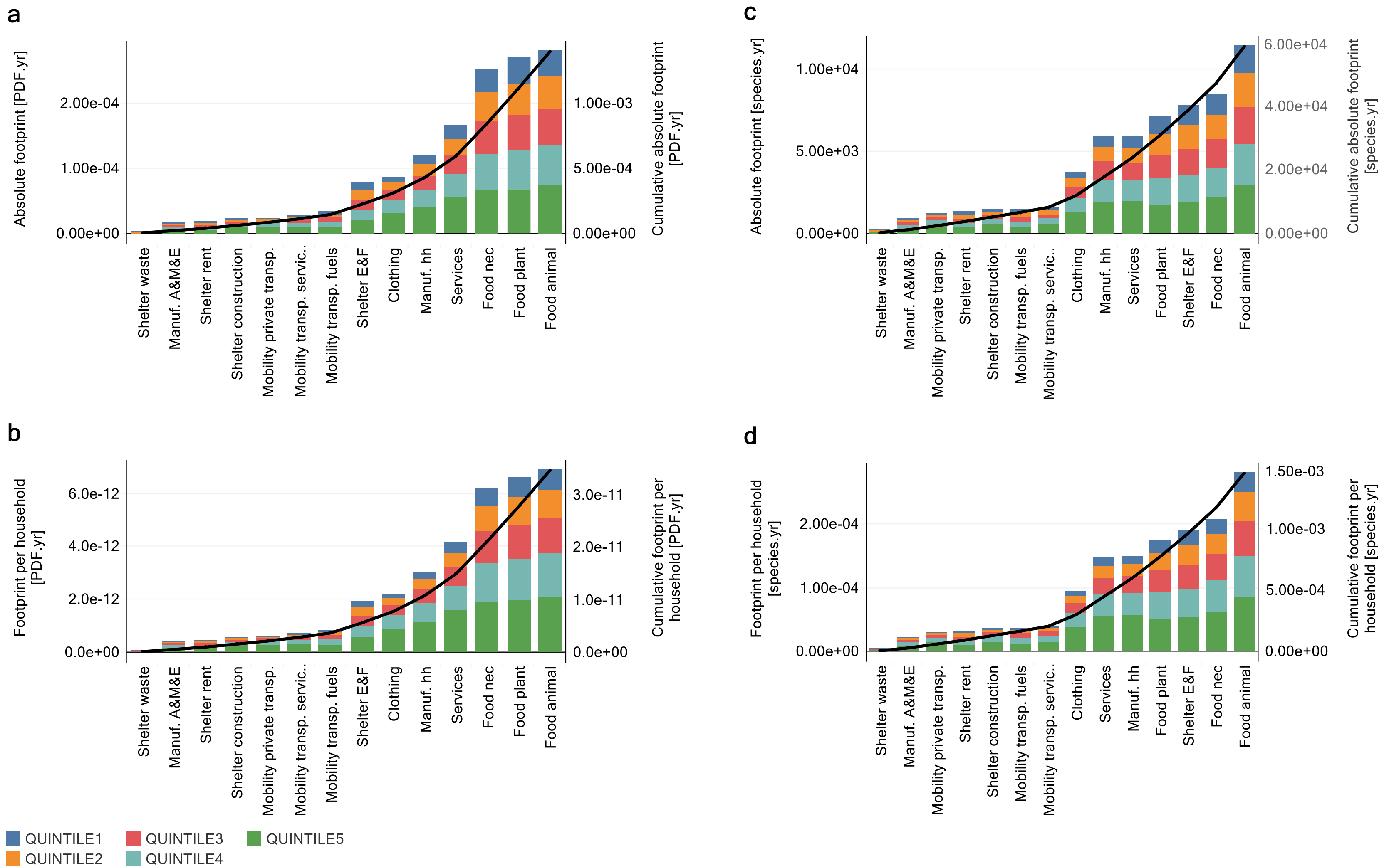

Figure S15: Biodiversity footprints according to LC-Impact and ReCiPe per income quintile in 2010. a) and c) show LC-Impact footprints; b) and d) show ReCiPe footprints. a) and c) are in absolute terms, whereas b) and d) are the footprints per income quintile per household. Norway is not included due to data availability.

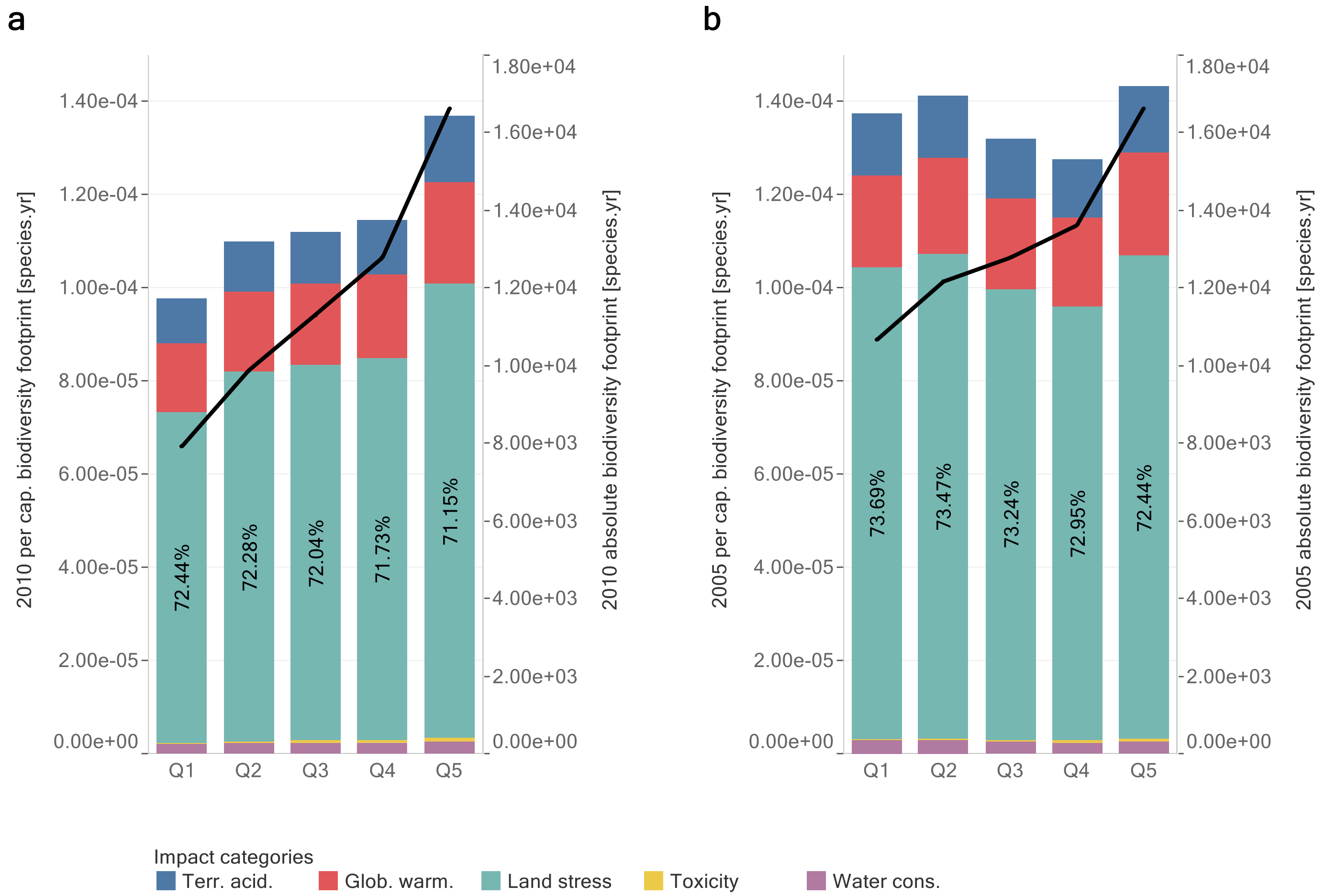

Figure S16: ReCiPe biodiversity footprints disaggregated by income quintiles. a) shows 2010 footprints, b) shows 2005 footprints. The primary axes describe per capita footprints, whereas the secondary axes scale absolute footprints. Colouring denotes different impact categories. Mind that the 2005 footprints do not include the contribution of Ireland and Sweden due to missing data; replacing these with 2010 data as in Figure 3 is not possible due to the nature of data. No data on income quintiles in Norway were available in either year.

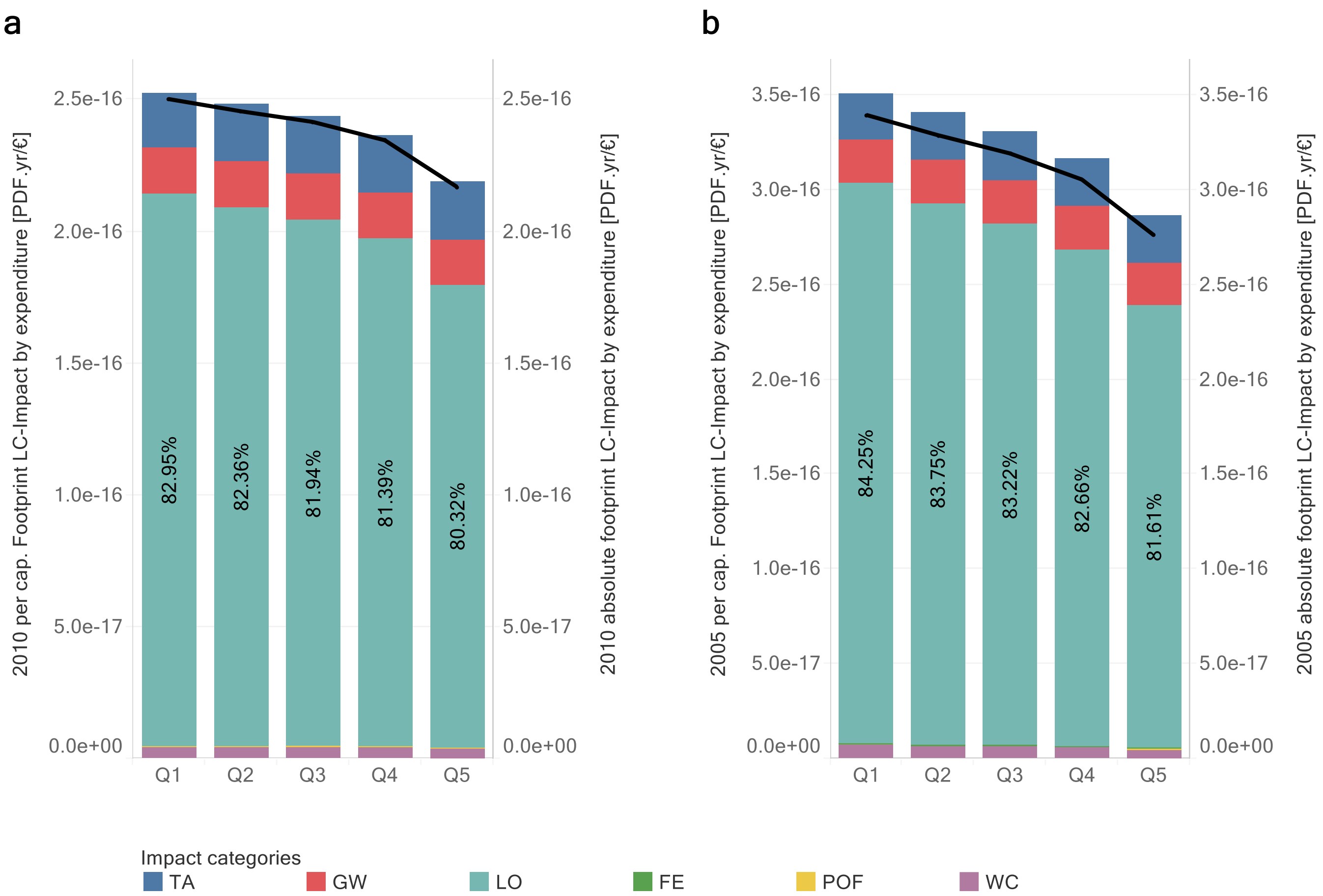

Figure S17: Normalised LC-Impact biodiversity footprints disaggregated by income quintiles for 2005 and 2010. Both per capita and absolute footprints were normalised against the balanced consumer expenditure (per capita and absolute, respectively). The primary axes describe per capita footprints, whereas the secondary axes scale absolute footprints. Colouring denotes different impact categories: FE – Freshwater eutrophication, GW – Global warming, LO – Land occupation, POF – Photochemical ozone formation, TA – Terrestrial acidification, WC – Water consumption. Mind that the 2005 footprints do not include the contribution of Ireland and Sweden due to missing data; replacing these with 2010 data as in Figure 3 is not possible due to the nature of data. No data on income quintiles in Norway were available in either year.

SI11. Degrees of urbanisation – map creation

Figure 3 in the main text shows a map depicting the absolute LC-Impact biodiversity footprints of European countries in 2010. This map makes use of the "degree of urbanisation" (DEG) classification by Eurostat (2018a) and is based on the GHS-SMOD grid (https://ghsl.jrc.ec.europa.eu/ghs_smod.php). This classification is based on population densities Figure S18:

- Cities are defined as densely populated areas: "at least 50% of the population lives in urban centres"
- Towns and suburbs are areas of intermediate density: "less than 50% of the population lives in rural grid cells and less than 50% of the population lives in urban centres"
- Rural areas are thinly populated: "more than 50% of the population lives in rural grid cells"
- For some regions, no data was available.

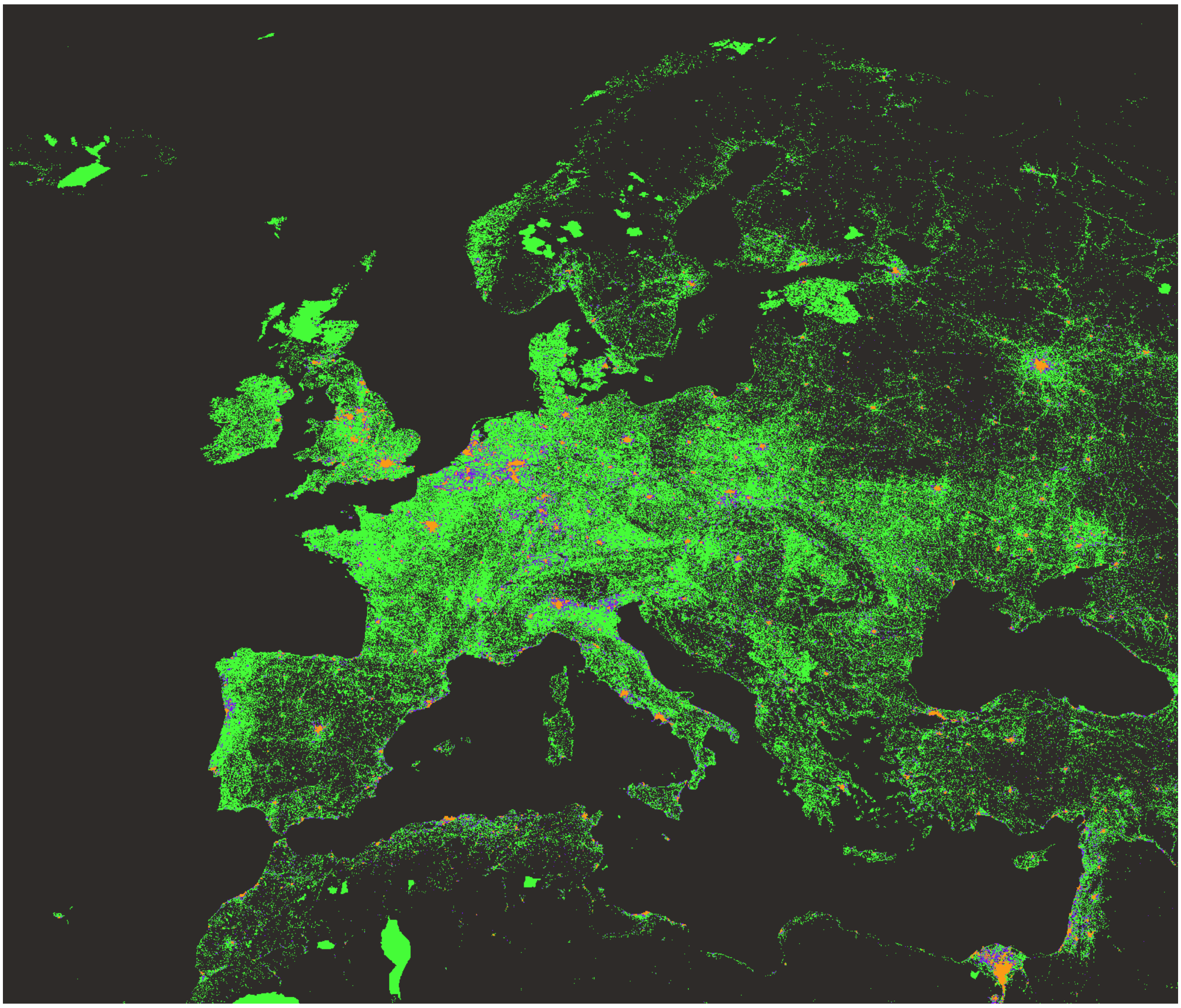

Figure S18: Degrees of urbanisation. The colours denote different degrees of urbanisation: green – rural, purple – town, orange – city, black – no data available. View limited to Europe. Source: (Eurostat, 2018a)

Figure 3 in the main text was then created by linking the biodiversity footprints of each European country with polygon sections of Figure S18. Martin Dorber (2018) of the Industrial Ecology programme at NTNU offered substantial help in this process. Under his guidance, the following steps were performed using ESRI (2017):

- Creating a new layer out of the Exiobase region layer, showing only the "Eurostat" countries covered in the present analysis
- using this selection for extracting the same area out of the original DEG raster file
- convert the thus created raster sub-section into polygons (multi-part features)
- adding biodiversity footprint data disaggregated by DEG as a table to the map
- spatially joining the footprint data disaggregated by DEG with the polygon layer
- creating four copies of this layer
- filtering each copy via a definition query for one grid code (individual DEGs)
- apply a graduated colours symbology to each copy, all of them following the same classification method (natural breaks ranging from 0 to the overall maximum, 10 classes)

Through this method, national biodiversity footprints disaggregated by DEG are allocated to the respective polygons. Of course, the individual pixels per country do not show the individual footprint per each human settlement in this country, but only the country average. However, with all settlements per country making up the country average per DEG, the thus created map provides a detailed insight into the sub-national level of each country's biodiversity footprint.

SI12. Discussing the choice of impact assessment methodology

The choice of impact assessment methodology for estimating impact footprints clearly influences the results. While LC-Impact footprints rely on spatially explicit endpoint characterisation factors, ReCiPe footprints applied here use globally averaged mid- to endpoint conversion factors. Apart from this difference in spatial differentiation, LC-Impact accounts for global species losses, whereas ReCiPe measures only local ones. For assessing the weight of these two aspects and others, a separate analysis would be required, which is out of the scope of the present study. It must be added that ReCiPe also provides country-specific mid- to endpoint conversion factors. The application of these was, however, not possible due to time constraints. Moreover, the ReCiPe footprints were calculated using midpoint characterisation factors included in EXIOBASE – to remain consistent, ReCiPe's midpoint characterisation factors would have to be used, but were also omitted due to limited resources.

In conjunction with the choice of impact assessment methodology, the corresponding metrics' roles must be highlighted. While LC-Impact measures the potentially disappeared fraction of species, ReCiPe accounts for direct species losses. Although different *per se*, they assess the same aspect of biodiversity, namely species richness. Hence, other facets of ecosystem well-being and biodiversity such as ecosystem function and structure are, to say the least, not in focus (Curran et al., 2011; Woods et al., 2017). Despite this critique and although ecological models describe ecosystem damages better and endpoint modelling in LCIA is constrained by major conceptual and data limitations, only the latter allows for a cross-impact assessment of multiple drivers (Curran et al., 2011; Curran et al., 2016). Especially the comparability of biodiversity indicators regarding spatial scales and across impact categories commends LCIA methods and is still a primary focus in its further development (Verones, Bare, et al., 2017; Woods et al., 2017). Combining this with MRIO was already done by Verones, Moran, et al. (2017) and is a further step into the elucidation of environmental cause-effect relationships, linking proximate causes and consequences as postulated by Hertwich (2012).

And yet, environmental causality is not fully reflected in the present approach. The assessment of species losses via an LCIA-MRIO link takes only a retrospective point of view. More specifically, biodiversity footprints only account for already existing losses (the ones present in the year of characterisation factor calculation). They do not account for the ones directly caused by final demand, due to the set-up of characterisation factors. Moreover, the respective characterisation factors are not developed based on total biodiversity, but only based on one or multiple species groups. In that regard, ReCiPe and LC-Impact differ in species coverage per impact category. ReCiPe uses mainly average species densities, whereas LC-Impact accounts for spatially explicit species richness and losses in the year of characterisation factor assessment. When it comes to the selection of drivers of biodiversity loss, it must be noted that in the present analysis many impact categories are left out, such as marine biotic depletion or invasive species. This has two reasons: first, LCIA data on these categories is only sparsely (if at all) available, and second, the attribution of impacts to, for instance, invasive species is not trivial. Similarly, no allocation of impacts due to illegal activities was possible. However, we assumed that the majority of environmental impacts are driven by legal economic activities, particularly via land use and the other here selected pressures. Some of the here stated and other limitations of LCIA in combination with MRIO are explained in, among others, Marques et al. (2017) and Verones, Moran, et al. (2017). Despite all these shortcomings, the combination of LCIA and MRIO is one of the few approaches that allow for regional top-down environmental assessments as means of identifying drivers on the production and/or demand side.

SI13. Coding and files

The analytical MRIO model was programmed using Matlab. Several scripts were created, all of which can be found in the electronic attachment. These scripts are:

- eurostat_converter.m, function (~100 lines): Selects sections of the retrieved Eurostat data, i.e. per year (consumption expenditure structure, mean consumption expenditure, household characteristics)
- Eurostat_struct_builder.m, function (~100 lines): in combination with the eurostat_converter.m file, this script creates a new structure of the selected data in per-country format
- CES_prep.m, main script I/II (~800 lines): reconciliation of CES data; also, preparation of GDP and population data
- Impact_calc.m, main script II/II (~750 lines): disaggregation of final demand and subsequent impact calculation for various shapes of final demand. The impact calculation was undertaken for pressure-, aggregated pressure-, LC-Impact impact-, and ReCiPe

impact-footprints. A section for a production layer decomposition is included as well as a one for plotting Lorenz curves

- Excel_write.m, print script (~250 lines): writes selected results into respective Excel spreadsheets
- Check_HHFD.m, test script (~70 lines): used to compare the results from the SLY calculation using either the computed disaggregated final demand or the originally provided final demand

Apart from these self-written scripts, other functions were applied that were provided by the supervisors or downloaded from matlab-file-exchange (respective documentations are found in the files):

- ginicoeff.m, function: calculates the Gini-coefficient
- lorenzcurve.m, function: prepares and plots a Lorenz-curve
- xlswrite1.m, function: fast method for writing in Excel spreadsheets
- piv2mat.m, function: transforms a data structure
- Extract_Trade_Matrix.m, function: calculates a trade matrix for a given year and country

The following data files were retrieved from Eurostat:

- hbs_str_t226.tsv: Structure of consumption expenditure by degree of urbanisation
- hbs_str_t223.tsv: Structure of consumption expenditure by income quintiles
- hbs_str_t225.tsv: Structure of consumption expenditure by age of reference person
- hbs_str_t224.tsv: Structure of consumption expenditure by type of household
- hbs_exp_t136.tsv: Mean consumption expenditure by degree of urbanisation
- hbs_exp_t133.tsv: Mean consumption expenditure by income quintiles
- hbs_exp_t135.tsv: Mean consumption expenditure by age of reference person
- hbs_exp_t134.tsv: Mean consumption expenditure by type of household
- hbs_car_t315.tsv: Household characteristics by degree of urbanisation
- hbs_car_t316.tsv: Household characteristics by main source of income
- hbs_car_t314.tsv: Household characteristics by age of reference person
- hbs_car_t313.tsv: Household characteristics by type of households

In addition, several files containing EXIOBASE data were provided by the supervisors (namely Alexandre Tisserant) and were used as data input:

- EXIOBASE_2010_HHFD_split_by_income_quintile.mat: includes, among others, country-specific HHFD for comparison, bridge matrices, and underreporting for the year 2010. For the present MRIO model, only the bridge matrices were used; due to data availability and the assumption that the differences would be negligible, the same bridge matrices were applied when preparing the 2005 data

- Final_Demand_BP_and_PP_2005and2010.mat: includes country-specific final demand in basic and purchasers' prices for the years 2005 and 2010
- IOT_2005_pxp.mat: includes basic IO data, such as A and S matrices, and country-specific population and GDP data, all for 2005
- IOT_2010_pxp_with_marginal_consumption.mat: same as above, but for 2010
- Number of Households.xls: contains the number of households per country and year

Multiple Excel-spreadsheets were created as direct data input, calculation outputs, or for further data analysis (additional spreadsheets can be found in the digital SI). Because many files are inter-linked, we recommend opening all files in parallel so that the respective links can be found automatically. It may, however, happen that some links need to be edited. The results in each footprint (fp) file are in the respective unit, i.e. PDF.yr or species.yr for both impact footprints and the relevant emission or resource use metrics for pressure and characterised pressure footprints (see the denominators in Tables S10 and S11). The respective files do not always contain headers and legends where needed; in such cases, the reader is referred to the code.

- CF_data_compilation.xlsx: contains the selected LC-Impact characterisation factors
- ReCiPe2016_CFs_20161004.xlsx: contains ReCiPe characterisation factors
- Impact_fp_LC_impact_2005.xlsx: contains raw LC-Impact biodiversity footprints and respective analyses for 2005
- Impact_fp_LC_impact_2010.xlsx: same as above but for 2010
- Impact_fp_ReCiPe_2005.xlsx: contains raw ReCiPe biodiversity footprints and respective analyses for 2005
- Impact_fp_ReCiPe_2010.xlsx: same as above but for 2010
- Pressure_agg_fp_2005.xlsx: contains raw characterised pressure footprints and respective analyses for 2005
- Pressure_agg_fp_2010.xlsx: same as above but for 2010
- Pressure_ fp_2005.xlsx: contains raw pressure footprints and respective analyses for 2005
- Pressure_ fp_2010.xlsx: same as above but for 2010
- Pop_HH_GDP_Exp_2005.xlsx: contains details on population, households, gross domestic product, and balanced consumer expenditures for 2005
- Pop_HH_GDP_Exp_2010.xlsx: same as above but for 2010
- Sector_conc_Ivanova_et_al.xlsx: contains the sector bridge matrix from Ivanova et al. (2017)
- Data_analysis_2005.xlsx: contains further analyses of footprints for 2005
- Data_analysis_2010.xlsx: same as above but for 2010
- Tableau_Total-Impact_LC-ReCiPe_2010.xlsx: contains a mash-up of the above data for visualisations using Tableau Desktop 2018.1.2 (2018).

Apart from the above Excel-files containing pressure and impact footprints, as well as data on GDP, populations, and households, several .mat-files were created as output:

- FinalDemandBPpxp_Eurostat_2005.mat: contains the reconciled final demand and household expenditure details as a result from the CES_prep.m script using 2005 data
- FinalDemandBPpxp_Eurostat_2010.mat: Same as above but for 2010
- FinalDemandBPpxp_2005_rearranged.mat: contains the disaggregated final demand, household expenditure details, as well as GDP and population data as a result from the Impact_calc.m script using 2005 data
- FinalDemandBPpxp_2010_rearranged.mat: same as above but for 2010 data
- Environmental_Accounts_prep_2005.mat: contains the labelling and other meta data or additional information in relation to the calculated footprints for 2005
- Environmental_Accounts_prep_2010.mat: same as above but for 2010 data
- Environmental_Accounts_2005.mat: contains the actual footprint calculation results for 2005
- Environmental_Accounts_2010.mat: same as above but for 2010

Data that was mentioned in the main text or in this supporting information, but is not included in the digital SI is available on request from the author.

SI14. Programs and applications used

Multiple programs and applications were used for preparing data, computing footprints, and visualising results. While the MS Office suite was used for both data preparation and analysis of the results, MATLAB version 9.3.0 (2017) was applied for CES data reconciliation, final demand disaggregation, computation of footprints, and similar data handling. ArcGIS version 10.6 from ESRI (2017) was used for deriving and preparing the LC-Impact characterisation factors. Data visualisations were created using Tableau Desktop 2018.1.2 (2018) and MS Excel.

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