Letter to the Editor

Ecological Footprint: Informative and evolving – A response to van den Bergh and Grazi (2014)

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ABSTRACT

Ecological Footprint accounting is used to track human demand on the Earth’s biological resource flows, and compares that demand with the Earth’s capacity to generate these flows. It is an evolving tool which has undergone many improvements alongside advancements in science and in response to critical review. Here we respond to van den Bergh and Grazi’s recent points of criticism toward Ecological Footprint accounting. While the authors suggest that new criticism is accumulating, the main issues appear to be the same. We suggest that the majority of the criticism is derived from the misconception that the Ecological Footprint measures land “use,” which cannot exceed land availability. In response to these criticisms, we aim here to summarize and further clarify the major points of debate and confusion and allow readers to determine the relevance of these issues. We conclude that much of the prior discussion and many of the points repeated here reflect a divergence in general philosophical or semantic perspectives.

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1. Introduction: what Ecological Footprint accounting does do

Ecological Footprint accounting is based on the simple principle that human demand competes for a finite amount of biologically productive space. In order to avoid overusing natural capital stocks, demand for the services these spaces produce should not exceed what they can renew. More specifically, resources should not be consumed faster than they are regenerated, waste should not be emitted faster than ecosystems can assimilate them, and both of these functions can compete for the same piece of biologically productive space.

Ecological Footprint accounts thus track one key aspect of the sustainability challenge by comparing human demand on the planet’s resources with the Earth’s supply of biologically productive areas. Maintaining human use of such resources and services within the planet’s regeneration capacity (or biocapacity) is a necessary, although not sufficient, condition for sustainable human societies and economies (Bastianoni et al., 2013).

Both demand and supply are measured in terms of areas that are adjusted for their respective productivity, which we call “global hectares”. A global hectare is a biologically productive hectare with world average productivity. Using this standardized measurement unit enables Footprint accounts to compare human demand against the biosphere’s ability to renew (see response to point 2 for additional details).

Of course, we recognize that Ecological Footprint accounts are not, and likely never will be, perfect. Since the inception of the national Footprint assessments in the early 1990s (Wackernagel and Rees, 1996; Wackernagel et al., 1999, 2002), we have continually worked on improvements with the advancement of scientific knowledge, improvement of underlying datasets and consideration of relevant criticisms. We are well aware of the issues raised by van den Bergh and Grazi dating back to van den Bergh and Verbruggen’s first paper (1999) and have implemented improvements in response to relevant concerns by revisiting topics such as carbon sequestration, grazing and fish accounting, and nuclear power in the accounts. Moreover, several additional methodology improvements are at the top of our research agenda for the forthcoming years (see Kitzes et al., 2009).

van den Bergh and Grazi advise against the use of the Ecological Footprint and the misleading indications that one could gain out of it; yet Footprint results and trends are consistent with those of other global sustainability and resource-use related studies (Vitousek et al., 1986; Imhoff et al., 2004; Krausmann et al., 2013; Barnosky et al., 2012; Steffen et al., 2015). If anything, Footprint results underestimate global overshoot and provide a minimum reference value for the magnitude of human demand on nature (Goldfinger et al., 2014). The results give a viable indication of how much the human economy takes from the biosphere compared to what is renewed, and the conservative figures show human societies are living beyond the budget of nature (Galli et al., 2014).

Opposite to what van den Bergh and Grazi claim, the underlying assumptions have not been changed while improving the methodology. However, due to such methodological changes, Footprint results from different editions of the National Footprint Accounts cannot be compared – as openly declared by Global Footprint Network’s authors (see Borucke et al., 2013).
Here we aim to step back from the back-and-forth debate which has occurred in various fora (Goldfinger et al., 2014; Wackernagel, 2014; Rees and Wackernagel, 2013, Global Footprint Network 2015). Instead, in addressing the eight points raised by van den Bergh and his colleagues, we strive to explain where we do not see the relevance of the criticism or where we see a fundamental disconnect between the stated purpose of Ecological Footprint Accounting and that which van den Bergh and Grazi would like it to do.

van den Bergh and Grazi contend that Ecological Footprint criticism has been accumulating in recent years. However, it should be noted that a small number of authors have written the majority of the recent critical articles in the last two years. At the same time, a larger, more diverse group of authors is increasingly applying Ecological Footprint accounting for resource management and policy support purposes (e.g., White, 2007; Niccolucci et al., 2007, 2012; Kissinger et al., 2011; Kuzyk, 2012; Jury et al., 2013; Lawrence and Robinson, 2014; Lambrechts and Van Liedekerke, 2014; Li et al., 2014; Rugani et al., 2014; Teixidó-Figuera and Duro, 2014; see also Bastianoni et al. (2013) for a comprehensive list) or proactively developing alternative Footprint approaches (e.g., Hopton and White, 2012; Ferg, 2014; Liu et al., 2014; Pelletier et al., 2014 – see also Galli, 2015) in an attempt to address some shortcomings of Global Footprint Network’s Ecological Footprint method.

Ultimately, it is up to Footprint users to judge whether the criticisms brought forward by van den Bergh and Grazi reduce or negate the utility of Ecological Footprint accounting.

2. Responses to the eight criticisms

1. The Ecological Footprint method represents “false concreteness”

van den Bergh and colleagues question the “concreteness” of the Ecological Footprint. Their main argument is that Ecological Footprint accounting gives a seemingly concrete, physical value to something they would consider “virtual.” Therefore, they claim that Footprint results make a false representation.

We point out that all flows tracked in Ecological Footprint accounts are real flows from real areas of land. Expressing these flows as a globally comparable unit, the global hectare, does not make them virtual.

A clarification of the overshoot concept is needed here: in traditional ecology, the term overshoot is used to indicate the state in which a population’s demands exceed its environment’s ability to support those demands (its carrying capacity). Note that “demand” for such ecosystem flows, which can exceed supply, is different from land “use,” which cannot exceed available land. In Footprint terms, overshoot occurs when a population’s demand on an ecosystem exceeds the capacity of that ecosystem to regenerate resource provisioning and regulatory services, leading to liquidation of natural capital stock (Monfreda et al., 2004). Overshoot is an excess use of flows which manifests as stock depletion. Ecological Footprint and biocapacity accounting track overshoot through the differences in real flows, not by assessing the change in stocks.

Additional (non-Footprint) measures should be used to monitor stock changes. For instance, if carbon concentration in the atmosphere increases, it indicates that there is a larger flow of emissions than the flow of sequestration. Some of the difference in the flows is seasonal or cyclical, some of it is cumulative. If all measures are done perfectly, changes in stocks should match differences in flows.

See also question #2 for more detail on the global hectare unit of measure and question #6 for more detail on carbon.

2. The use of global hectares contributes to the hypothetical character of the Ecological Footprint

The authors claim that it is misleading and hard to understand the mixing of productivity and area within the global hectare concept. They suggest biomass as a possible better alternative to land area but note themselves that biomass would not be a good proxy. The authors also state that the use of the global hectare measure is confusing as a global hectare is not always a hectare.

We acknowledge that the definition of a global hectare is indeed complex and realize that Global Footprint Network might have contributed to the confusion by sometimes suggesting, for ease in communication, that a global hectare is simply a physical hectare of land.

Rather, a global hectare is a hectare-equivalent unit representing the capacity of a hectare of land with world-average productivity (across all croplands, grazing lands, forests and fishing grounds on the planet) to provide ecosystem services that people demand. Since technology, climate, environmental conditions and management change every year, so differs the global hectare for every year.

Dividing the total biocapacity of Earth by the total number of bioproductive hectares yields the value of an average productive hectare – a “global hectare”. Each global hectare represents the same biological productivity – a particular fraction of the earth’s total biocapacity.

As reported in Galli (2015), a parallel with the unit CO2 equivalent (CO2eq) can further clarify the nature of this unit. The release of one ton of CO2eq does not mean that this amount has actually been released, as there is no molecule called CO2eq. Rather, it means that various greenhouse gases with the equivalent global warming potential of one ton of CO2 have been released. Similarly, when a person in USA is said to have, on average, an Ecological Footprint of seven gha, it does not mean that seven hectares of physical land in the USA are used. It means that the equivalent capacity of seven global hectares of productive land is needed to produce (via photosynthesis) the resources and services that the average resident in USA demands – this biocapacity could be anywhere in the world.

Is there enough biocapacity on Earth to satisfy the demands of humanity on the biosphere? The ability to clearly answer this question and compare the bioproductivity available (biocapacity) and bioproductivity demanded (Ecological Footprint) in terms of area requirements expressed in a globally comparable unit (global hectares) is arguably one of the strengths of the National Footprint Accounts.

Is measuring Footprint versus biocapacity in a common unit relevant? We believe that human demand exceeding biocapacity supply is a significant risk, and that national and international decision-makers are relevant actors to address this risk. Therefore, we use a standardized measurement unit (the global hectare) that is comparable across the globe. This global hectare can easily be converted into local hectares with a simple calculation (Galli et al., 2007). Some researchers, for example, have found it relevant to focus on regional differences within China (Zhang et al., 2009) or Australia (Lenzen and Murray, 2001) and have chosen to use national hectares. Others (Galli et al., 2007; Niccolucci et al., 2008) have found actual hectares the most appropriate unit of measurement to track changes in local resource management.

3. Footprint accounting implies that land use is the all-important sustainability variable and 4. The Footprint does not capture all relevant environmental pressures

In point 3, the Ecological Footprint is criticized for claiming to be “the all-important” indicator, although we explicitly claim
otherwise. Then, in point 4, the Ecological Footprint methodology is criticized for not capturing all relevant sustainability pressures. We recognize that the Ecological Footprint is far from sufficient in addressing all relevant sustainability pressures and disagree that the Footprint implies land use is the all-important indicator.

All recent Global Footprint Network publications have clearly stated that no single indicator is a complete measure of sustainability, and that together, biocapacity and Ecological Footprint “measure one main aspect of sustainability only – how much biocapacity humans demand in comparison to how much is available—not all aspects of sustainability, nor all environmental concerns” (Borucke et al., 2013).

We agree that biocapacity should include all demands on biologically productive area that compete for space. Indeed, release of toxics or “noise disturbing animals” could affect biocapacity and should, in theory, be included. However, because of the methodology’s underlying assumptions (see Wackernagel et al., 2002), only those resources, pollutants or services that can be measured in terms of biologically productive surfaces are included in the Ecological Footprint. When first conceived (Rees, 1992; Wackernagel, 1994), the Ecological Footprint methodology was limited by data availability and scientific knowledge. The current methodology has undergone many refinements and in our opinion, is suited to be a first approximation of human demand on biocapacity. However, it can still be improved by incorporating new data and advances in scientific knowledge. Global Footprint Network welcomes scientific collaboration with researchers and scientists interested in such improvements. One important line of research Global Footprint Network seeks to pursue involves the fragility of biocapacity, i.e., how and to what extent impacts of current use might reduce future biocapacity.

5. The Footprint aggregates distinct environmental problems using arbitrary weights

van den Bergh and Grazi argue that biocapacity and Ecological Footprint are aggregates of environmental pressures which cannot be disaggregated and contain unsubstantiated implicit weights. Then it is noted that one single number cannot capture a complex phenomenon like sustainability.

We agree that biocapacity cannot be decoupled from many of the listed pressures, which affect biocapacity. “Weights” are not arbitrary, but are determined according to an activity’s relative demand on biocapacity, or an area’s relative productivity. More detail on the execution at the national level is available in our method paper (Borucke et al., 2013). Ecological Footprint calculations are accounting systems based on a specific question, not arbitrary indices adding incongruent aspects using weighting. They are structurally similar to GHG accounts (where everything is analyzed from the perspective of greenhouse gas equivalents), or material flow accounts (where everything is aggregated according to their weight).

6. Calculation of the carbon Footprint component is based on an arbitrary “sustainable energy scenario”

Here and in point 2, van den Bergh and Grazi argue that the Ecological Footprint is based on an arbitrary energy scenario. In reality, Ecological Footprint accounting is not based on any energy or other pre-set scenarios. Rather, it accounts for competing demands on limited biologically productive space. One competing demand is waste absorption (based on the widely accepted assumption that increasing CO2 concentration in the atmosphere is leaving a burden to future generations). Consequently, Footprint accounts track how much biocapacity is needed to sequester anthropogenic CO2. If certain policies or actions lead to reduced CO2 emissions or CO2 is removed before it is emitted to the atmosphere, the carbon Footprint would be smaller. In other words, the accounts are sensitive to both reduced emissions and changed sequestration capacity.

However, if humanity plans to be more efficient in the future, the Ecological Footprint of today does not currently capture this intention because the results have not yet occurred (Footprint accounting tracks what is, not what could be). For further discussion, see Mancini et al. (2015).

7. Footprint applications focus on countries rather than on “bioregions”

van den Bergh and Grazi “of course agree that it is a plus if an indicator can provide a result for policy-relevant geographic areas,” and note that it also makes sense for biocapacity to be accounted in bioregions. We stress that nation-level data is particularly relevant to policymakers. Still, we concur that biocapacity and Footprint assessments would also be useful for bioregions.

8. Measurement of national ecological deficits supports antitrade sentiments

van den Bergh offer examples of our statements that they claim to be anti-trade and follow with questions and statements aimed to illustrate the benefits of trade. We agree trade can effectively take advantage of specialization and therefore generate great benefits to people and regions. Ecological Footprint accounting does not dispute this. Rather it offers a metric to track flows in embodied biocapacity.

An ecological deficit (reserve) occurs when the Ecological Footprint of a population exceeds (stays within) the biocapacity of the area available to that population. We believe the terms “deficit” and “reserve” are descriptive, rather than judgmental.

Finally, van den Bergh and Grazi challenge Ecological Footprint accounting by comparing it to a model for optimizing the spatial configuration of economies. Why one should contradict the other is unclear to us. Footprint accounts make no judgments about optimal allocation – the accounts merely track demand on biocapacity.

3. Conclusion

Here, we have responded to the eight concerns raised by van den Bergh and Grazi and summarized common points of departure on these issues and suggest that Footprint users judge whether these issues are fundamental barriers to using the accounts. Wackernagel (2014) pointed out that the Footprint answers a different research question than that which van den Bergh and Grazi imply it addresses, thus making most of their criticisms difficult to apply to Ecological Footprint science.

Our opinion is that in order to determine the utility of Ecological Footprint accounting, four fundamental questions must first be addressed in the following logical sequence:

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2 The term Ecological Footprint was originally developed by Wackernagel (1994) with advisor William Rees as a representation of appropriated bioproductive area. The carbon Footprint is one of six Ecological Footprint components which compete for bioproductive surface area, and it represents the area of Forest needed to sequester waste carbon emissions from fossil fuel burning at world average forest carbon sequestration rate. More recent usages of “Carbon Footprint” (Wright et al., 2013) express greenhouse gas emissions as CO2 or CO2 equivalents, without conversion to land area. A detailed assessment of the distinction between the carbon component of the Ecological Footprint and the Carbon Footprint indicator can be found in Galli et al. (2012).

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1. What is the underlying research question of Footprint accounts? It is important to answer the question to ensure both parties talk about the same thing, since a name alone can mean different things to different people. Ecological Footprint accounting attempts to answer the following question: how much do people demand from ecosystems compared to what those ecosystems (or the biosphere as a whole) can regenerate? van den Bergh and Grazi’s criticism implies that they believe the Footprint addresses a different research question, reducing the pertinence of their arguments (van den Bergh and Grazi did not declare what they think the research question for the Footprint is).

2. If the question the Footprint addresses is clear, is the question relevant to policy concerns? If the underlying question is clear but not relevant to the identified problem area, then the tool is not useful. van den Bergh and Grazi neither acknowledge nor contest the research question that we believe the Footprint addresses, let alone debate whether the research question is relevant. They merely state that they do not deem the Footprint to be policy relevant, which we also address below.

3. If the Footprint question is relevant, are there more accurate methods available elsewhere for answering its particular question? van den Bergh and Grazi do not question Footprint Accounts on the basis that more accurate methods are available. Rather, they note, “Perhaps it is of consolation to footprint devotees to know that other efforts to arrive at an aggregate environmental indicator have failed as well.” In fact, the failure of other indicators brings little consolation. Rather, we worry that decision-makers lack relevant sustainability information, including how much their economies or projects demand compared to what ecosystems can renew. While such information does not guarantee sustainable outcomes, the absence thereof makes such outcomes far less likely.

4. If there are no better methods to answer the Footprint question, is society better off without the results this method generates? Even if van den Bergh and Grazi found the core research question clear and relevant and did not find better answers, they still could make the case that society would be better off without the results this method generates. This would be the case if they could show that the answers are so poor that they mislead more than they inform. However, as we have pointed out, Footprint results are in line with many other studies addressing humanity’s dependence on the Earth’s resources and services.

Discussing this sequence would reveal useful criticism that we welcome to improve the Footprint accounts. In the meantime, we continue to improve the National Footprint Accounts following our research agenda (including the one published by Kitzes et al., 2009) and expert recommendations.

Finally, as van den Bergh and Grazi have discussed in detail the policy usefulness of the Ecological Footprint, we would like to close this reply by acknowledging that much has yet to be explored regarding the role of the Ecological Footprint (and in general all systemic indicators) within the policy development and implementation process. We have seen policy applications of Ecological Footprint accounting around the world, from Canada, Canada, to Beijing, China. But we acknowledge that concerns relative to the Ecological Footprint’s relevance in policy setting are likely due to methodological shortcomings (Kitzes et al., 2009) and Ecological Footprint users’ tendency to report only aggregate results. Assessing the policy relevance of Ecological Footprint accounting requires a clear definition of what “policy relevant” means. For instance, could it be that many of the (mono-dimensional) assessment tools and indicators upon which our current policies are built are not relevant to measure and monitor the complexity of sustainability? Could new systemic, cross-cutting indicators complement traditional tools in planning for sustainability? These are all open questions that we continue to investigate. We encourage Footprint users and interested readers to review Galli (2015), which aims to initiate a discussion on the potential policy implications of Ecological Footprint accounting.

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