Ecological Footprint and Biocapacity Germany's Nowcast for 2020

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Nowcasting

The National Footprint and Biocapacity Accounts (NFA) build on official data sets, which come with a time delay. Typically, the latest data point is about 4 years delayed, meaning that the 2021 edition of the National Footprint and Biocapacity Accounts reports results up to 2017.

Economic indicators like GDP are reported in a timely fashion, sometimes even by quarter, and most democratically elected governments have had elections within the last four years. So, although Ecological Footprint and biocapacity does not shift rapidly and historical trends are informative, 4-year-old data may seem inadequate.

For this reason, Global Footprint Network offers nowcasting, which is distinct from forecasting. Forecasting uses models to extrapolate data into the future, based on assumptions of how the forecasted item operates. Nowcasting uses actual data, but that data may be spottier, from other, less official, sources, or only provide proxy information. For instance, more recent trend data on aspects of the NFA, such as car usage, electricity intensity, and change in housing stock, can show relative changes of those aspects, and may be superimposed over the more complete NFAs that end 4 years prior.

This report documents the nowcasting produced for Germany based on the National Footprint and Biocapacity Accounts 2021 edition – extending the time series from 2017 up to 2020.

Note: the principles of nowcasting are similar for any country, but actual data sets vary depending on data availability within the country.

Starting Point: National Footprint and Biocapacity Accounts

The nowcast are extensions of the National Footprint and Biocapacity Accounts, including the latest results (2017) and time series (1961-2017). These accounts are comprehensive biophysical balance sheets that compare countries' demand on nature with what the planet or that country's ecosystems can renew. They build on the premise that materially, the most limiting factor for the human economy is the capacity of our planet's ecosystems (its "biocapacity"). They inform us about every country's unique sustainability challenges, including climate change and resource constraints.

Recognizing the overarching biological constraints to human metabolisms, these accounts focus on tracking the country's material demands (Footprint, red line in figure below).

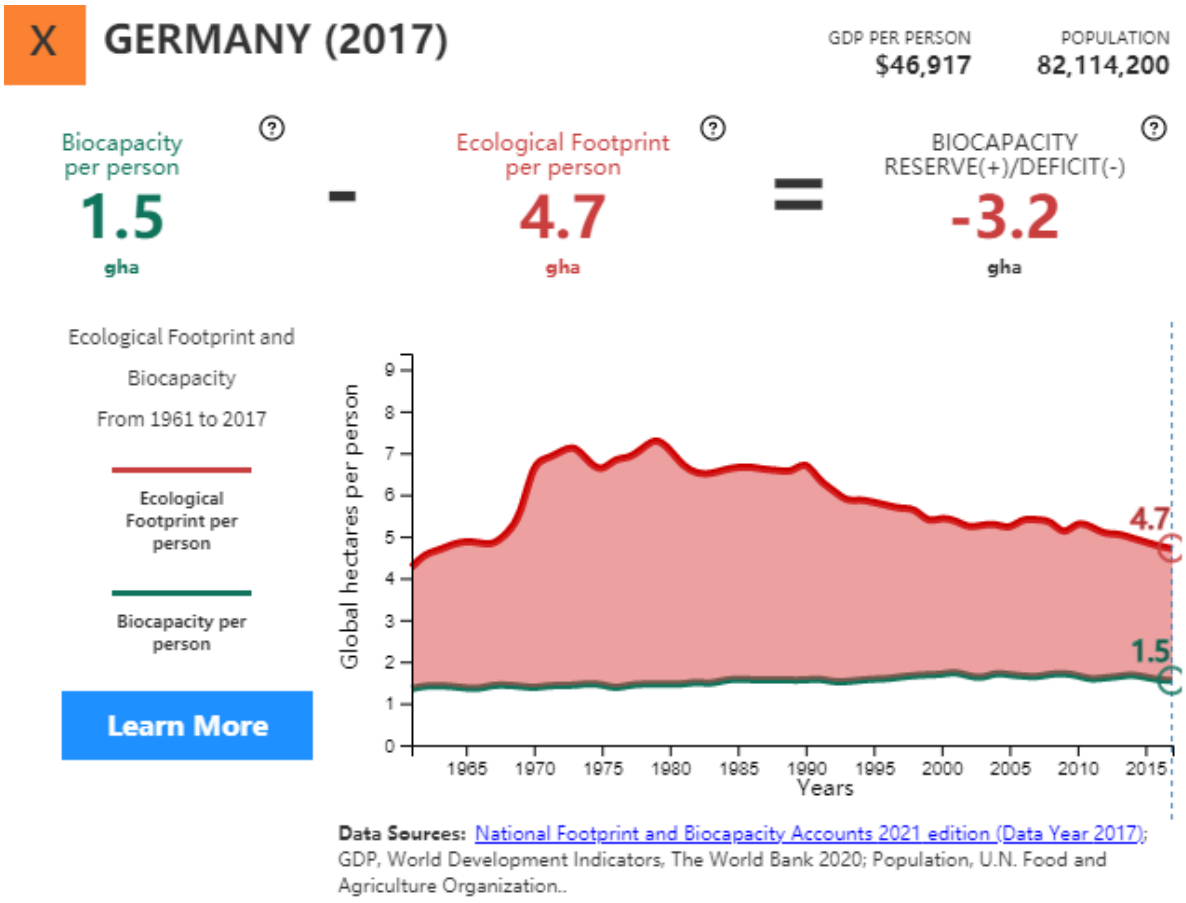

Figure 1 – Germany's Ecological Footprint and its domestic biocapacity in global hectares per person from 1961 to 2017 (2021 edition). data.footprintnetwork.org

That demand is contrasted with how much biologically productive area is available within the country (the country's biocapacity, green line in figure above), or how much is available worldwide. Figure 1 shows the per person results for Germany. The same results can also be depicted as absolutes, i.e., the total Ecological Footprint and total biocapacity of Germany. The ratio between Footprint and biocapacity shown in both perspectives is the same.

While Footprint and biocapacity assessments are possible at any scale, the *NFAs* are a useful reference point as they are based on data from UN statistics, rather than data that has been chosen arbitrarily. They are also based on clear accounting principles.[1]

The accounts have been published and improved upon annually since 1997. They have also been tested by over ten national government agencies. The mechanics of the accounts and the results they have produced have been confirmed. For instance, both the French and the Swiss government reviews reproduced the results within 3%. (Some agencies did not like the implications of the results, but no agency has proven them to be inaccurate.)

The Footprint's underlying research question is straightforward: How much mutually exclusive, biologically productive area[2] is necessary to renew people's demand for nature's products and services? The demand includes:

- food, fibre, timber,
- accommodation of roads and structures,
- waste absorption, incl. CO_2 from fossil fuel.

Our priority is to make the accounts more trusted and neutral. Thus, we have established a new organization with external partners for this very purpose. This new home for the National Footprint and Biocapacity Accounts is the "Footprint Data Foundation" (www.FoDaFo.org), initiated by York University and Global Footprint Network. Its sole purpose is to maintain and improve the accounts. The new institutional arrangement

[1] National Footprint and Biocapacity Accounts are the reference point for all other Footprint analyses at other scales, down to the product level. Footprint standards (www.footprintstandards.org) provide guidance on how to make assessments at any scale consistent.

[2] Before adding up the areas, they are first productivity adjusted, hence measured in global hectares. This makes biocapacity and Footprints comparable across time and space, since the areas are weighed proportionally to their biocapacity.

for producing the accounts is governed through an independent board to secure neutrality and scientific rigor.

Results of the National Footprint and Biocapacity Accounts are available on the open data platform at data.footprintnetwork.org, as well as through a downloadable spreadsheet workbook (public data package). The 2021 edition, which is the newest edition, was released in November 2020. Its results stretch to 2017.

Step Two: Breaking down the National Footprint and Biocapacity Accounts by consumption activity

The National Footprint and Biocapacity Accounts describe the consumption within a country by looking at production, imports and exports. To apply detailed nowcasting, we re-categorize the data into sub-components which align with the local and more recent data. These data are used as proxies to estimate the recent changes in each Footprint component. Most often, and in the case of Germany, the majority of the recent data is available by subcomponents arranged in categories by consumer activity.

The technique to break down the National Footprint and Biocapacity Accounts results into meaningful components is called **Multi-Regional Input Output** assessment (MRIO). The assessment uses financial data to estimate resource flows between countries' major economic sectors and to sub-categorize national Footprint data into more specific consumption and industry related components. This allows the Ecological Footprint data from the National Footprint and Biocapacity Accounts to be allocated to final demand consumption from each economic sector, including the footprint associated with the entire supply chain.

Taking this data one step further, one key output from our MRIO is the **Consumption -Land-Use Matrix (CLUM).**[3] The CLUM is produced by

[3] MRIO analysis requires two input data sets, the **National Footprint and Biocapacity Accounts** (see results here), and the Global Trade Analysis Project (**GTAP)** (for details see: https://www.gtap.agecon.purdue.edu/), a widely used financial input-output database maintained by Purdue University. The GTAP database provides data on purchases between 65 economic sectors as well as the final consumers in 141 countries. The remaining countries are grouped into 20 regions. Because the Footprint Accounts are biophysical, but the GTAP data set is financial, our MRIO assessments apply prices from GTAP to estimate the associated resource flows (expressed as "embodied biocapacity").

allocating data from economic sectors to consumer activities. CLUMs provide a breakdown of a country's consumption Footprint into its components. Table 1 shows a simplified version of the German CLUM. It uses the UN's COICOP consumption categories – grouped in food, shelter, mobility, goods, and services.

Consumption Category or Sector	2017 CLUM Germany						
[gha person-1]	Cropland	Grazing Land	Forest Products	Fishing Grounds	Built-up Land	Carbon	TOTAL
Total:	**0.80**	**0.18**	**0.35**	**0.05**	**0.10**	**3.22**	**4.70**
Food	0.49	0.08	0.03	0.03	0.01	0.20	0.84
Housing	0.02	0.01	0.09	0.00	0.02	1.05	1.19
Personal Transportation	0.03	0.01	0.07	0.00	0.02	0.86	0.99
Goods	0.18	0.06	0.10	0.01	0.03	0.52	0.89
Services	0.09	0.02	0.06	0.00	0.03	0.59	0.80

Table 1 – The simplified 5 category Consumption Land-Use Matrix (CLUM) for Germany (2017); the full resolution disaggregated dataset used for the nowcast contains 48 detailed categories.

Step Three: Adjust each CLUM cell using local time trend data

Using local data, each CLUM matrix cell is adjusted. For this task, we used several German datasets:

1) Household Consumption Expenditures[4] in purchasing power adjusted Euros
2) Construction investment[4]

Using these two data sets, an **"Input Output" analysis** is performed, an approach pioneered by economist Wassily Leontief, and initially brought to life in the 1950s. Essentially, it is linear algebra, and it is data and calculation intensive. (For an overview on this method, check here)
Global Footprint Network performs MRIO assessments for all available countries in the National Footprint and Biocapacity Accounts for 2004, 2007, 2011, 2014. These are the only years for which a GTAP data set is available. Currently we use GTAP version 10 (www.gtap.agecon.purdue.edu/databases/v10/index.aspx). For more on MRIO visit explanations here on the Global Footprint Network website

[4] DESTATIS; National accounts - Final consumption expenditure of households (price-adjusted, chain linked): Germany; 3-digit COICOP; Government and non-governmental sector construction investment and new construction.

3) Paper production[5]
4) CO_2 intensity of electricity production (Global average)[6]
5) CO_2 intensity of electricity production (National average)[7]
6) Greenhouse gas emissions by sector[8]

Economic Data

Household consumption expenditure data was used as an input for most calculations either on its own or in combination with other data. Statistics exist for Germany that track how much has been spent for each consumption category while adjusting for year-to-year price fluctuation in that category. For this dataset, we assume that the change in price-adjusted spending reflects the physical increase in demand in this category. Additionally, construction investment data was used to estimate the change in built up land footprint.

CO_2 Intensity of electricity production

We adjust the nowcast when there are known changes in resource intensity for a category. For example, in Germany, a reduction in power from coal power plants resulted in a reduction in the carbon intensity per kWh electricity. In this case, the price adjusted expenditure accurately reflects the amount of electricity purchased, and the additional CO_2 emissions per unit of electricity generation must be accounted for to reflect changes in total carbon footprint associated with household electricity consumption. This assumes that electricity consumed by households in Germany is consumed at the same intensity as electricity produced in Germany, and does not account for imported electricity.

The Footprint values in the CLUM include embedded footprint within the full supply chain, and therefore we made a conservative estimate for several categories (see table 2 above) to account for the global changes in CO_2 intensity within the global supply chain. This estimate is conservative because Germany's CO_2 intensity of energy production decreased in recent years by a far greater amount than global average; For the period of 2017-2020, Germany's reduction is estimated to be ~10% per year, compared to the global average of ~0.6%. It is likely that

[5] VDP; https://www.vdp-online.de/industrie/statistik; Paper, cardboard, paperboard and raw materials production, sales, consumption by main types and overall
[6] International Energy Agency (IEA) 2020; https://www.iea.org/reports/energy-efficiency-2020
[7] Federal Environment Agency (UBA); Development of the specific carbon dioxide emissions of the German electricity mix from 1990 to 2019; *estimated here for 2020.
[8] Federal Environment Agency (UBA); National Trend Tables for the German Atmospheric Emission Reporting 1990-2020.

some proportion of Germany's consumption was produced entirely within the domestic supply chain (rather than by trade partners).

CLUM Category	Cropland	Grazing Land	Forest Products	Fishing Grounds	Built-up Land	Carbon
Bread and Cereals	1	1	1,2,3	1	2	4
Meat	1	1	1,2,3	1	2	4
Fish and Seafood	1	1	1,2,3	1	2	4
Dairy	1	1	1,2,3	1	2	4
Vegetables, Fruit, nuts	1	1	1,2,3	1	2	4
Other Food	1	1	1,2,3	1	2	4
Non-alcoholic beverages	1	1	1,2,3	1	2	4
Alcoholic beverages	1	1	1,2,3	1	2	4
Actual rentals for housing	1	1	1,2,3	1	2	4
Imputed rentals for housing	1	1	1,2,3	1	2	4
Maintenance and repair of the dwelling	1	1	1,2,3	1	2	4
Water supply and miscellaneous services relating to the dwelling	1	1	1,2,3	1	2	4
Electricity, gas and other fuels	1	1	1,2,3	1	2	1,5
Direct HH Emissions	1	1	1,2,3	1	2	6
Services for household maintenance	1	1	1,2,3	1	2	4
Purchase of vehicles	1	1	1,2,3	1	2	6
Operation of personal transport equipment	1	1	1,2,3	1	2	6
Transport services	1	1	1,2,3	1	2	6
Clothing	1	1	1,2,3	1	2	4
Footwear	1	1	1,2,3	1	2	4
Furniture and furnishings, carpets and other floor coverings	1	1	1,2,3	1	2	4
Household textiles	1	1	1,2,3	1	2	4
Household appliances	1	1	1,2,3	1	2	4
Glassware, tableware and household utensils	1	1	1,2,3	1	2	4
Tools and equipment for house and garden	1	1	1,2,3	1	2	4
Medical products, appliances and equipment	1	1	1,2,3	1	2	4
Telephone and telefax equipment	1	1	1,2,3	1	2	4
Audio-visual, photographic and information processing equipment	1	1	1,2,3	1	2	4
Other major durables for recreation and culture	1	1	1,2,3	1	2	4
Other recreational items and equipment, gardens and pets	1	1	1,2,3	1	2	4
Newspapers, books and stationery	1	1	1,2,3	1	2	4
Goods for household maintenance	1	1	1,2,3	1	2	4
Tobacco	1	1	1,2,3	1	2	4
Out-patient services	1	1	1,2,3	1	2	4
Hospital services	1	1	1,2,3	1	2	4
Postal services	1	1	1,2,3	1	2	4
Telephone and telefax services	1	1	1,2,3	1	2	4
Recreational and cultural services	1	1	1,2,3	1	2	4
Package holidays	1	1	1,2,3	1	2	4
Pre-primary and primary education	1	1	1,2,3	1	2	4
Catering services	1	1	1,2,3	1	2	4
Accommodation services	1	1	1,2,3	1	2	4
Personal care	1	1	1,2,3	1	2	4
Personal effects n. e. c.	1	1	1,2,3	1	2	4
Social protection	1	1	1,2,3	1	2	4
Insurance	1	1	1,2,3	1	2	4
Financial services n. e. c.	1	1	1,2,3	1	2	4
Other services n. e. c.	1	1	1,2,3	1	2	4

Table 2 – Data Input used to adjust Consumption Land-Use Matrix (CLUM) to nowcast German Ecological Footprint. Numbers indicate data source: 1) Household Consumption Expenditures; 2) Construction investment; 3) Paper production; 4) CO_2 intensity of electricity production (Global); 5) CO_2 intensity of electricity production (National); and 6) Greenhouse gas emissions by sector.

Physical Data

We used more specific data which physically described the various components. In these cases, we assume that the change in production in recent years can approximate consumption. For instance, in the time series of emissions in the mobility sector, we assume that changes in CO_2 emissions associated with road traffic, air transport (domestic and international), and rail traffic, represented change in mobility categories for households. In these cases, physical data is assumed to be a more reliable and direct representation compared to economic data.

Biocapacity Nowcast

Biocapacity for Germany was nowcasted by using historical trends as input to predict subsequent years. Starting in 2014, the most recent trends indicate a slight decrease in biocapacity. This was due to two factors: a slight decrease in Germany's crop yields, and a slight increase in global crop yields. An increase in global crop yields effectively means that the biological value of a global hectare increased after 2014 (analogous to deflation of a national currency in economic terms). Both factors contributed to the effective decreasing biocapacity of Germany observed from 2014-2017.

Results for Germany (2020)

See Figure 2 below for the nowcasting results for Germany. The biocapacity for Germany in 2020 is estimated at 1.5 global hectares per person. In contrast, Germany's Ecological Footprint per person is 4.4 global hectares per person, of which 66% is carbon Footprint.

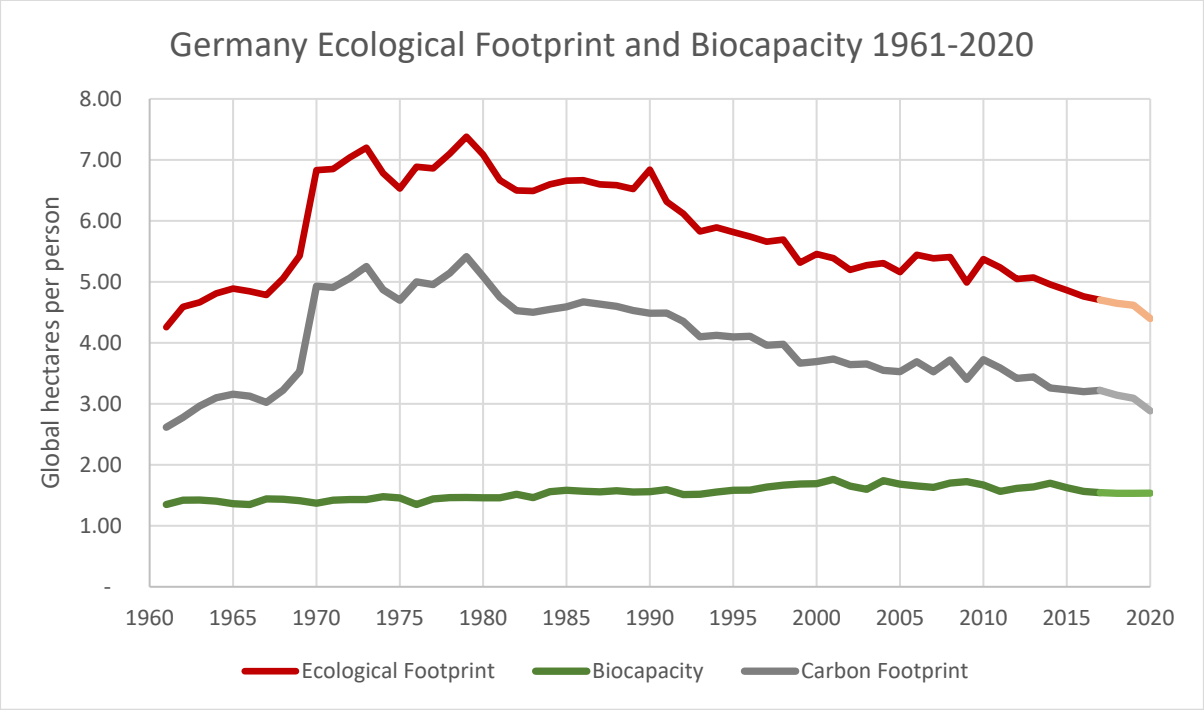

Figure 2 – Germany's per person Ecological Footprint and biocapacity from 1960 to 2020 in global hectares per person. The red line is the total Ecological Footprint per person, and the grey line is the Carbon Footprint per person (a subset of the Ecological Footprint). The green line shows the biocapacity per person in Germany. The results for 2018-2020 are nowcast estimates, the other data points are directly taken from the National Footprint and Biocapacity Accounts, 2021 edition.

Note that in 2020, the Ecological Footprint was significantly reduced in the early part of the year, most significantly in Q2. But in Q3 and Q4, even though the lockdowns persisted, consumption seemed to increase again, reversing some of the reduction. These transitional effects during the year are not shown in this assessment since it averages demand and regeneration on an annual basis. This also allows to even out natural fluctuations in consumption and regeneration across the year. Still, overall, the per person carbon Footprint declined in 2020 compared to 2019.

Acknowledgment

We thank Prof Hans Diefenbacher, Dr. Benjamin Held and FEST e.V. (Institut für Interdisziplinäre Forschung) for the German data collection, as well as their financial contribution towards producing this nowcasting of the German Footprint and biocapacity.

Relevant publicly available references:

- Video introduction to the National Footprint and Biocapacity Accounts, including its underlying method: www.youtube.com/watch?v=_T5M3MiPfW4 (2.5 min)
- Ecological Footprint Results for countries: data.footprintnetwork.org
- The basics on the accounting method, including a guidebook on the National Footprint and Biocapacity Accounts and a detailed paper on the calculation method are provided here: www.footprintnetwork.org/resources/data/
- Accounting Method and recent improvements in the accounting method: www.mdpi.com/2079-9276/7/3/58 (*Ecological Footprint Accounting for Countries: Updates and Results of the National Footprint Accounts, 2012–2018*)
- A free click-through license gives you access to a sample workbook (for Hungary 2014) www.footprintnetwork.org/licenses/workbook-learning-license
- A comprehensive workbook with the newest Ecological Footprint and biocapacity contains key results www.footprintnetwork.org/licenses/public-data-package-free
- Limitations and Criticisms: The Ecological Footprint has clear limitations. And criticism drives the scientific process. All sincere criticism is helpful, whether based on misunderstandings, new insights, or flaws in the methodology. Global Footprint Network summarized www.footprintnetwork.org/our-work/ecological-footprint/limitations-and-criticisms/
- Nowcasting the global Ecological Footprint for Earth Overshoot 2020: www.overshootday.org/2020-calculation

- Rationale and interpretation of country level results: www.mdpi.com/2071-1050/11/7/2164/htm (*Defying the Footprint Oracle: Implications of Country Resource Trends*); Section 2 discusses key premises, comparison Footprint to other metrics

- EU *fact sheet on the Ecological Footprint* and results for European countries on the EEA website

- Biodiversity and other Ecological Footprint applications: https://www.bipindicators.net/indicators/ecological-footprint; https://doi.org/10.1016/j.biocon.2013.10.019 (Ecological Footprint: Implications for biodiversity)

- The new platform for National Footprint and Biocapacity Accounts: www.FoDaFo.org; footprint.info.yorku.ca; www.OnePlanetAlliance.org

- Short video from 2005 explaining the Footprint concepts in 3 min (it is a bit dated, but still provides an accurate description) www.youtube.com/watch?v=EjyrAHzthTo. A more general introduction is provided in the new book Ecological Footprint: Managing our Biocapacity Budget

- EEA updated the Ecological Footprint results last in 2020 (based on a report Global Footprint Network produced for them) https://www.eea.europa.eu/data-and-maps/indicators/ecological-footprint-of-european-countries-2/assessment

- The EC's Beyond GDP website recently updated the description of Ecological Footprint accounting here