MAIA
Mapping and Assessment for
Integrated ecosystem Accounting

The MAIA country fact sheets summarize the state of affairs on natural capital accounting (NCA) in the countries connected to the MAIA project. They serve as an accessible overview and entry point for collaboration. The factsheets describe the needs from policy, society, science and business for the use of NCA, give an overview of the ongoing and published research -including knowledge gaps- in the country, include contact details and an overview of national partners and stakeholders involved in the accounts. Information in this document is based on MAIA Deliverables and exchanges, and the content is reviewed, co-authored and updated by MAIA-liaison persons in the participating country. This version was updated on August 5th 2022.

Country fact sheet:

Germany (DE)

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and more generally, the German Nature Conservation Agency (Bundesamt für Naturschutz BfN) and Thünen Institute for Int. Forestry & Forest Economics, as well as the Federal Statistical Office of Germany.

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Summary

In the last couple of years, in Germany, there have been quite some advances with regard to NCA. Through diverse research projects, a fundamental base of different ecosystem accounts has been compiled and is recently being updated and extended. In addition to that, Ecosystem Accounting also took root in the Federal Statistical Office in Germany. As a result, in 2021 the first official German ecosystem extent account has been published. The knowledge gathered in the process will – in the end - lead to a reporting system to inform policy on the full range of ecological and economic developments, including some effects of policy decisions, as well as the impacts of different private activities. While the Federal Statistical Office publishes the official and regular accounts, they benefit from pilot accounts and the scientific work of the different scientific institutions.

Altogether, in Germany, pilot as well as official ecosystem extent accounts are available on a national scale. Far-reaching aspects of an ecosystem condition account have already been incorporated into the research-based service accounts. An official ecosystem condition account is under development. By means of the research activities, ecosystem services pilot accounts in biophysical and economic terms have been developed.

In general, the data sources for ecosystems accounts pose some issues due to accuracy, quality, scope and regularity of surveys and data collections. Furthermore, there are no professional knowledge gaps or difficulties recorded in Germany and the Federal Statistical Office's entry into the work on ecosystem accounting has significantly increased the chance of a more continuous provision of resources.

The time is right to more comprehensively inform policy makers of the potential and advantages of natural capital accounting, stressing the importance of sufficient funding and cooperation, both national and international including knowledge sharing, not only within the MAIA project, but also involving experts from amongst others KIP INCA, and UNSD.

Country policy priorities for developing natural capital accounts

The priorities for Germany were to take the first steps in implementing the accounting framework, focussing on biodiversity conservation and related targets in urban and rural areas. The knowledge gathered in this process supports the development of a reporting system based on a comprehensive set of ecosystem accounts to inform policy on the full range of ecological and economic effects of policy decisions that involve our natural capital, i.e. amongst others the quality of our ecosystems, nature´s biotic resources including nature conservation issues.

Ecosystem accounting data provides basic information on the state and economic relevance of ecosystems and their services. This needs to be on a regular basis, comparable and statistically valid. Through various extensive research projects and official ecosystem accounting activities of the Federal Statistical Office first steps towards such a comprehensive set of information and data has been made in the last couple of years. The benefits of developing ecosystem accounts are numerous. They include the creation of a harmonized data base, elucidate the intersectoral physical and economic relations between nature, economy and society and provide data for land use decisions and environmental policies. For the latter this also includes scenarios for alternative policy programs, for example on renewable energy, infrastructure and forest and agricultural policies.

The specific aim of the MAIA project in Germany is to analyse the theoretical framework and the methodological principles concerning ecosystem accounting and to support their application. A key priority is to develop the pilot accounts related to issues that are of high political relevance and closely related to biodiversity conservation targets in urban areas and the countryside (land conversion, green urban areas, biodiversity accounting). Based on the experiences made with the pilots, a roadmap will be developed for a comprehensive ecosystem and ecosystem services reporting system. This will be fully integrated into the SEEA and thus linked to the central accounting framework. It will be used to inform policy on the full range of ecological and economic effects of policy decisions and a new step of a new understanding of national welfare: Natural capital as an integrated part of well-being and wealth of Germany, like productive capital, as well as human and social capital.
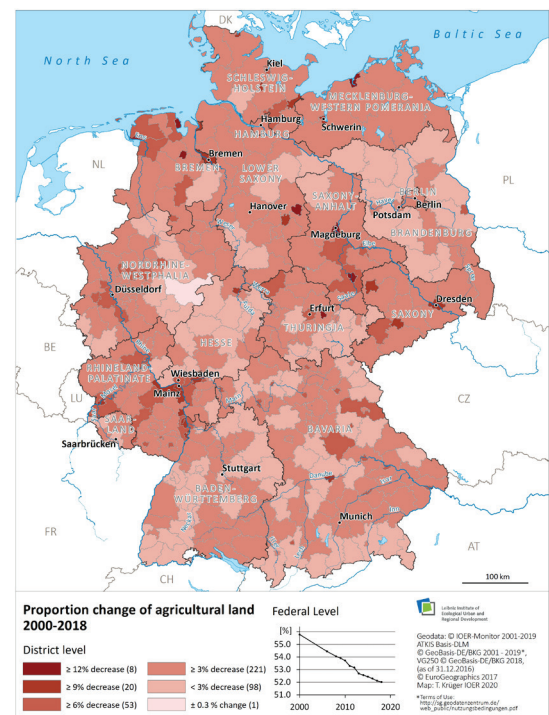
Accounts developed and under development

Summary table of pilot accounts

Account		Ecosystem Types / Ecosystem Services	Link to research
Accounts for ecosystem assets	Ecosystem extent account	**All ecosystems***	Grunewald et al., 2020
	Ecosystem condition account	**All ecosystems**	
	Ecosystem monetary asset account		
Accounts for ecosystem services	Ecosystem services supply and use table - physical terms	**Natural soil fertility of cropland and grassland***	Grunewald et al., 2021a,b
		Soil erosion mitigation*	Syrbe et al., 2018
		Pollination service potential*	Meier et al., 2021
		Recreation services*	Hermes et al., 2018
		Amenity value of public urban green spaces*	Grunewald et al., 2021a,b, Ekinci et al., 2022a
		Appreciation of species and habitat services*	Schweppe-Kraft et al., 2020
		Climate gas mitigation*	Grunewald et al., 2021b
		Timber of woodlands*	Elsasser et al., 2020, Elsasser et al., 2021
		Carbon sequestration of woodlands*	Elsasser et al., 2020, Elsasser et al., 2021
		Recreation services of forests for local residents*	Elsasser et al., 2020, Elsasser et al., 2021
		Services of forests for nature protection and landscape amenity*	Elsasser et al., 2020, Elsasser et al., 2021
		*Urban climate regulation**	Syrbe et al., 2022
	Ecosystem services supply and use table - monetary terms	**Natural soil fertility of cropland and grassland***	Grunewald et al., 2021a,b
		Amenity value of public urban green spaces*	Grunewald et al., 2021a,b
		Appreciation of species and habitat services*	Schweppe-Kraft et al., 2020, Ekinci et al., 2022b
		Climate gas mitigation*	
		Timber of woodlands*	Elsasser et al., 2020, Elsasser et al., 2021
		Carbon sequestration of woodlands*	Elsasser et al., 2020, Elsasser et al., 2021
		Recreation services of forests for local residents*	Elsasser et al., 2020, Elsasser et al., 2021
		Services of forests for nature protection and landscape amenity*	Elsasser et al., 2020, Elsasser et al., 2021
		Recreation services*	
Thematic accounts		**Biodiversity**	Schweppe-Kraft et al., 2020

Summary table of official accounts

Account		Ecosystem Types / Ecosystem Services	Link to research
Accounts for ecosystem assets	Ecosystem extent account	**All ecosystems**	Destatis (2021)
	Ecosystem condition account	**All ecosystems**	
	Ecosystem monetary asset account		
Accounts for ecosystem services	Ecosystem services supply and use table - physical terms	**All ecosystems**	
	Ecosystem services supply and use table - monetary terms	**All ecosystems**	
Thematic accounts			

Proportion change of agricultural land 2000-2018

District level
- ≥ 12% decrease (8)
- ≥ 9% decrease (20)
- ≥ 6% decrease (53)
- ≥ 3% decrease (221)
- < 3% decrease (98)
- ± 0.3 % change (1)

Federal Level

Figures source: Grunewald et al. (2020)

Scale	State of development
National	Finished
Regional	Ongoing
<u>Local</u>	None ongoing or published
*Highlighted in the fact sheet	

Summary overview of highlight accounting projects

Pilot Ecosystem Extent account

Within the research project funded by the Nature Conservation Agency, a nationwide uniform system of ecosystem type classifications that can consistently deal with diverse data sources on the extent and condition of ecosystems has been created. GIS land-use and ecosystem data that is compatible with EU-wide approaches or with other regularly collected data sources were combined and blended, for example, from sample-based surveys, to generate a complete, updatable picture of the state of Germany's ecosystems (Grunewald, et al. 2020). Allocation tables with different classes or levels (layers) enable an ecosystem extent accounting, which are used to help draw up balances

(area balances, status balances, ecosystem service balances) and can be further detailed, depending on the respective task.

A total of 35 CLC-Classes (minimum 1 ha resolution), 13 ecosystem subclasses, 5 ecosystem main classes on the basis of the "LBM-DE" (Digitales Landbedeckungsmodell für Deutschland/digital land cover model for Germany) were considered in the ecosystem typology with additional polygons added representing linear landscape elements (roads/alleys, rivers, treelines, hedges, rocks/stone ridges) by buffering topographical (ATKIS/German Official Topographic-Cartographic Information System) data and with about 300 subtypes differentiated by type and condition on the basis of reporting for the Habitats Directive, WFD-reporting, High Nature Value farmland survey, National Forest Inventory, agricultural land use statistics, land use statistics for settlements, industry and transport. The data used are from 2012, 2015 and 2018 and it is planned to integrate the updated data of 2021.

Ecosystem Services pilot accounts

The pilot accounts for Ecosystem Services in Germany cover many ES with finished and on-going accounts (table above, see also Grunewald et al. 2021a). Ecosystem service accounts in biophysical and economic terms have been developed for Natural soil fertility of cropland and grassland, Amenity value of public urban green spaces, Appreciation of species and habitats services, Timber and climate gas mitigation. Biophysical ecosystem services accounts are done for Soil erosion mitigation, Pollination service potential and Recreation services. Accounts of Climate gas mitigation and economic accounts of Recreation services are on-going. A more elaborate explanation of these ES accounts can be found in the table below.

In addition, a conceptual proposal for an ecosystem condition account is on the way and tangible proposals are developed on how processed data from different sources (public available remote sensing and geo-data, official statistics, HNV mapping, forest inventory data, etc.) can be efficiently exchanged and fed into common aggregation and evaluation models (e.g. recreation evaluation, demand for urban green spaces).

Ecosystem Service	Coverage	Years	Physical measure / model	Economic valuation method
Natural soil fertility of cropland and grassland	National - For all grasslands and croplands that are under agricultural use or were converted to a different use	2012 2015 2018	Müncheberger Soil Quality Rating classifying a site according to its productivity when used as cropland or grassland, the scale was calibrated with the help of winter wheat and winter rye yields	Agricultural land rent for soils with a specific SQR, calculated via regression
Soil erosion mitigation	National	2012 2015	Calculation of soil erosion (tonnes) with the Universal Soil Loss Equation based on typical C-factors for the real land use / land cover and for bare soil as the reference situation; effect of linear elements is calculated with the length (L) factor for a situation with and without linear elements	No economic valuation
Pollination service potential	National	2015	Relative density of pollinators depending on flower supply, suitability as nesting habitat and distance (according to Zulian et al. 2013)	Economic evaluation not yet planned
Urban climate regulation	All settlements > 50,000 inhabitants	2018	Ongoing work - according to Zardo et al. 2017	No economic valuation planned
Climate gas mitigation	National (all terrestrial ecosystem types included) - Finalized: mapping of carbon stocks in soils and vegetation for 2015 Ongoing: mapping of carbon sequestration and GHG emissions	2015 2018	Green House Gas emissions and carbon sequestration according to LULUCF (Peatland services according to SEEA-EA) Stocks for 2015 finalized and mitigation services ongoing	Current price on carbon markets; long term mitigation cost to reach the 1.5 degree target
Recreation	National - Potential supply and demand (matching approach) and modelled use for 2015	2015 2018	Matching of potential supply (ecosystem specific weighted landscape heterogeneity) and potential demand (accessibility weighted population density) modelled use on the basis of a Germany-wide representative survey of recreational activities Additionally for National Parks, Nature Parks (IUCN category IV) and Biosphere Reserves: Visitor counting and analysis	Planned - German-wide: share of travel that can be statistically explained by the naturalness of ecosystems at destination. Comparison with simulated exchange values for National parks and other large Nature Conservation areas as well as residence near forests based on already available Travel Cost Analysis (TCA) and Contingent Valuation (TC) studies
Amenity value of public urban green spaces	National	Spatial data for 2018; population in 100 x 100m cell according to 2011 census	Green space supply is measured in hectare public green space in 1km radius around place of residence; service is measured as increment of individual well-being that is related to an increase in actual supply of one hectare	Hectare public green space in 1km radius around place of residence a) related to house prices (hedonic pricing method); b) related to individual well-being; which is also correlated with income (experienced preference method) Both methods are complementary and not rivalrous
Services for Nature Conservation (Other terms used for this service: existence value [CICES], appreciation of species and habitats services)	National	2015 2018	Biotope Point Approach "Biotope Points" are widely employed in Germany to determine the no-net loss when, according to nature conservation law, impacts on biological diversity need to be offset by the upgrading or development of new habitats. They take into account characteristics of ecosystems such as naturalness, age, the occurrence of endangered species or the degree of threat to the ecosystem itself. Biotope Points were determined nationwide to all existing ecosystems synthesizing consistently all existing comprehensive data sources on the type and condition of ecosystems (LBM-DE and land use statistics, agricultural statistics, Habitats Directive and WFD reporting, National Forest Inventory, High Nature Value farmland survey)	The average cost spent to produce future biotope development with a value of one biotope value point discounted to the present time was taken as the price of an incremental increase in appreciation of species and habitat services and multiplied with the sum of all Biotope Points in Germany to end at the value of the stock of species and habitats that produce appreciation of species and habitat services. The yearly service can be calculated as the infinite annuity of the stock value using an appropriate discount rate (here: 3%)
Timber for woodlands ecosystems	national municipalities, mapped at county level	2018 LBM. DE data; tree species composition according to 2012 Federal Forest Inventory	Timber increment (estimated from Federal Forest Inventory data)	Potential gross sales revenues at current prices
Carbon sequestration for woodlands ecosystems	national - municipalities, mapped at county level	see above	Increase of carbon storage in woodlands and in timber products; additionally calculated: Climate mitigation by substitution of alternative non-timber products by timber products (calculated by "DFWR-Klimarechner" model)	Current price on compliance markets for carbon (EU-ETS) (or, less preferably, abatement cost estimates); possibly by suitable global Social Cost of Carbon estimates that user the same discount rate as used elsewhere in the accounting system (see Edens et al. 2019 for details)
Recreation for woodlands ecosystems	national - municipalities, mapped at county level	see above	Number of visits in forests near living place extrapolated with 2011 census data	Contingent Valuation (willingness to pay for an annual ticket to get access to a forest near the living place, results include consumer surplus); method suitable for deriving a simulated price
"Appreciation of species and habitats services" for woodlands ecosystems	national - counties, mapped at county level	see above	Forest bird diversity index (based at number of breeding pairs, as estimated in the Atlas of German Breeding Birds (ADEBAR), 2015)	Willingness to pay for an increment of species diversity (choice experiment, results include consumer surplus); method suitable for deriving a simulated price

Development of official national ecosystem accounts

In 2020, the Federal Statistical Office of Germany has started its work on assembling nationwide, spatially and temporally consistent ecosystem accounts. Building on the broad experience and knowledge base of ecosystem research in Germany and the SEEA EA framework, a standardized nationwide system of accounts is developed stepwise, with a special focus on time-consistent and automated accounting process.

In the first step, the ecosystem extent account has been produced for the timesteps 2015 and 2018. Building upon the experience of the pilot extent account produced by Grunewald et al (2020) and the guidance of the SEEA EA (2021), the area of Germany, including the German Exclusive Economic Zone (EEZ) in the North Sea and Baltic Sea, is assigned to one of 74 ecosystem classes without neither gaps nor overlaps. The resulting extent account makes it possible to record the extent of the various ecosystems and their changes over time. Due to the flexible design of the national classification of ecosystems and semi-automatic programming it is possible to calculate further timesteps quick and efficiently (Bellingen et al., 2021). The publication of the extent account covers a comprehensive set of account tables, as well as an interactive online viewer. The publication of the gridded geodata is planned, but for the moment only available upon request.

Currently, the Federal Statistical Office is working on assembling a comprehensive ecosystem condition account. That account follows the SEEA EA (2021) guidelines closely, so that the condition of ecosystems is described based on a set of variables and indicators. These variables and indicators are broadly categorized in three groups of the Ecosystem Condition Typology (SEEA EA 2021): Abiotic, Biotic and Landscape Characteristics. It is planned that first results are going to be published in the first half of 2023. The condition account monitors the integrity, stability and resilience of ecosystems and serves as input for the calculation of ecosystem services, which will constitute the next step in the development of official and regular ecosystem accounts at the Federal Statistical Office.

Figure:

Map of National Ecosystem Groups (cells colored by dominant class). Source: Federal Statistical Office Germany (2022)

Figure:

Map of National Ecosystem Classes of Group Broadleaf Forests (cells colored by dominant class). Source: Federal Statistical Office Germany (2022)

Knowledge gaps and difficulties for developing natural capital accounts

In general, uncertainty about continuous and nationwide data sources pose some issues due to accuracy, quality, scope and regularity of surveys and data collections. For the assembling and the regular update of the nationwide extent account, a wide range of data sets is available to classify ecosystems. However, for specific ecosystems, such as hedgerows or orchard meadows, the quality of the extent account could be still improved if countrywide standardized and high-resolution data sets became available.

With regard to the ecosystem condition account, an already detected data gap is biotic data, e.g. biodiversity or species abundance. Right now, the available biotic data is based on only few sampling spots, making it impossible to disaggregate the data below the national level. While field observations in protected areas like Natura 2000 are good, ecosystem accounts need sufficient data for every area. An intermediate solution could be a potential habitat analysis, where a model uses satellite data as well as data of field observation for validation. Another issue worth of mentioning is a delay in the provision of datasets, which can be attributed to the COVID-19 pandemic. New satellite products, specifically with focus on certain ecosystems could improve the development of even more detailed ecosystem accounts. Next to the issue of data availability, challenges arise with regard to the aggregation of data and information.

More specifically, regarding the pilot account of natural soil fertility, regressions between soil fertility indicators and yields show that there is
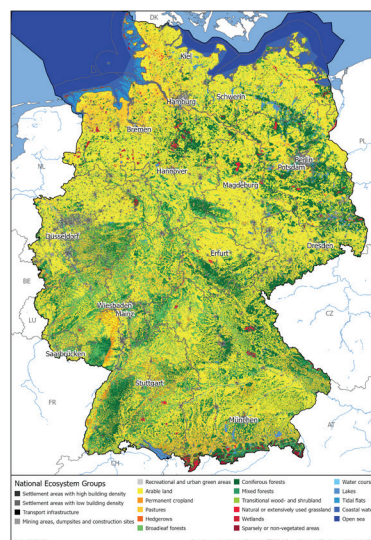
still need for additional research to better disentangle the contribution of soils from the contributions of anthropogenic factors to production. The calculation of amenity values of urban green space is based on data from different sources and years. There should be a recalculation based on more recent and harmonised data. The cost/price basis for the monetary valuation of services for nature conservation ("appreciation of ecosystems and species services") could be made more market-oriented by using the prices charged by the various conservation banking institutions in Germany for the compensation of detrimental effects on biodiversity caused by land use change. For the other ES accounts there are also still many questions regarding the methods and data for an economic evaluation.

The entry of the Federal Statistical Office into the work on ecosystem accounting has significantly increased the opportunity for a more continuous provision of data and resources for ecosystem accounting on the basis of an inter-institutional data management system yet to be developed. This creates opportunities for the development of a comprehensive condition account, the further inclusion of additional data and the refinement of already applied and the development of new methods for ecosystem accounting.

Since the SEEA EA framework has been adopted as statistical standard by the United Nations, further important steps have been worked out, which not only raise awareness of Ecosystem Accounting but furthermore lead to the adoption of the proposal to amend Regulation No (EU) 691/2011 on European environmental accounts on July 11th 2022. So the way is paved for regularly ecosystem accounts in every member state of the EU. Therefore, the Federal Statistical Office continues the work on Ecosystem Accounting.
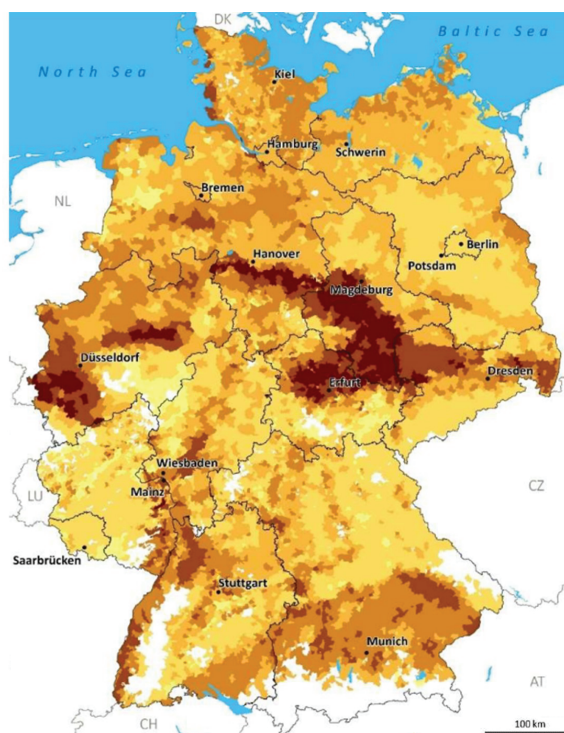
Support needs for developing natural capital accounts

Based on MAIA D3.2 (Annex 6 section 6 and 7); D5.1 (Annex 3 section 6e, 7 and 8)

It is important to obtain and maintain sufficient resources and close cooperation between the different organizations/ agencies involved in NCA. Specifically for and between those who deliver the basic data, design biophysical and monetary evaluation models and that are responsible for the coherency of the national accounting system. The time is right to inform policy makers and other decision makers in Germany more comprehensively about the potential and advantage of using ecosystem accounts, and the implications for an integrated ecological-economic thinking.

However, different kinds of "agenda setting" depend on new activities of the scientific community as well as the political and administrative willingness to use such integrated economic-ecological tools. Therefore, it will be important to improve the knowledge transfer between the statistical/scientific communities and policy makers. In addition, the development of a communication strategy could demonstrate the advantages of SEEA EA for different stakeholders and the public.

Next to national cooperation, also international cooperation between the MAIA MS and beyond is important for knowledge exchange about what works well and what does not in the accounting context. It would also be useful to call on previous expertise and to invite a.o. KIP INCA and UNSD experts to attend expert workshops in Germany. In general, the project and the approach used in Germany is on track.

Biomass provisioning service of agricultural land

Geodaten: SQR-Raster
© BGR 2013 LBM-DE 2012
© GeoBasis-DE/BKG 2016*, VG250
© GeoBasis-DE/BKG 2018,
Gebietsstand vom 31.12.2016
© EuroGeographics 2017
* Terms of use:
http://sg.geodatenzentrum.de/web_public/
nutzungsbedingungen.pdf
Map: S.Meier, R.-U. Syrbe, IOER
2020

Physical value: Mean values of the Soil-Quality Rating (SQR) for each municipality

<35	35 - <50	50 - <60	60 - <70	70 - <85	≥85	No data

Monetary service flow: Extrapolated estimated mean agricultural lease for each municipality. Euros per hectare per year:

<168	>168 -240	>240 -289	>289 -337	>337 -409	>409

Appreciation of ecosystem and species service (habitat maintenance service)

Geodaten:
LBM-DE 2012 © BGR 2013
Map: R.-U. Syrbe, S. Meier, IOER
2020

* Terms of use:
http://sg.geodatenzentrum.de/web_public/
nutzungsbedingungen.pdf

Physical value: Biotope points per hectare

1-2	>2-6	>6-8	>8-10	-11.8	-12.3	-13.3	-16.1	-17.0	>17

Monetary stock value: Average restoration costs to create a biotope development with a present value of one biotope point. Thousand euros per hectare:

3.6 -7.3	>7.3 -21.8	>21.8 -29.1	>29.1 -36.3	>36.3 -42.9	>42.9 -44.7	>44.7 -48.3	>48.3 -58.5	>58.5 -61.8	>61.8

Monetary service flow: Annuity of average restoration costs per biotope point. Euros per hectare per year:

109 -218	>218 -654	>654 -872	>872 -1090	>1090 -1286	>1286 -1341	>1341 -1450	>1450 -1755	>1755 -1853	>1853

Figure

Main ecosystem types in (left) and ecosystem subtypes (right) used in Germany to assess extent accounts. Source: Grunewald, et al. (2020).

Involved partners and stakeholders

Based on D5.1 (Annex 6 section 2);

European NCA stakeholder day

Government	Research	Private sector or NGO
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)	Leibniz Institute of Ecological Urban and Regional Development Dresden	
Federal Agency for Nature Conservation (BfN)	Thünen Institute	
Federal Statistical Office	Leibniz University Hannover, Institute of Physical Geography and Landscape Ecology	
Other governmental institutions (such as the German Environment Agency and the Federal Agency for Cartography and Geodesy)		

Figure:

Publicly accessible greenspace (left) and amenity services (right)

Publicly accessible greenspace

Physical flow (indicator):
Hectares within 1km around residence

0 | >0-50 | >50-100 | >100-150 | >150-200 | >200-250 | >250-314

Amenity services
(Hectares of greenspaces in 1km of residence × simulated price per hectare × number of households)

Monetary service flow:
Millions of euros per year per 2km × 2km grid square

0 | >0 - 1 | >1 - 2 | >2 - 10 | >10 - 30 | >30 - 50 | >50 - 218

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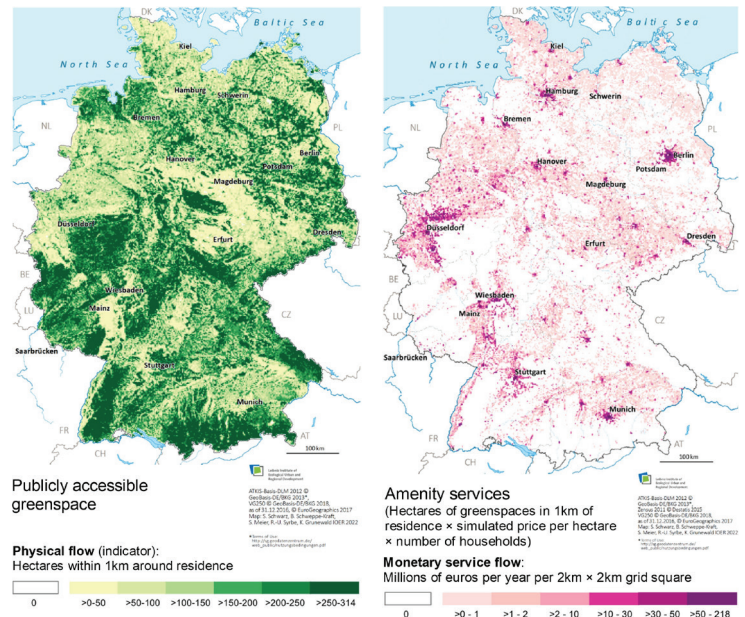
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