

Material stocks and sustainable resource use in the United States of America from 1870 to 2017

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Motivation

- More than half of all extracted materials worldwide are used to build and maintain material stocks of manufactured capital in infrastructures, buildings and durable goods. Material stocks provide services to societies but also drive material and energy flows and contribute to socio-ecological challenges like climate change. Understanding stock dynamics is therefore of paramount importance for developing strategies to reconcile societal wellbeing and ecological sustainability. In this study we estimate stocks for the USA from 1870 to 2017 and analyze their connection to material and energy flows.

Research Questions

- What share of all consumed materials is used for building and maintaining stocks?
- How did stocks develop over time, what is their size and composition?
- How large are stocks of the USA in comparison to the world and other countries?
- How have energy consumption and CO₂ emissions evolved in relation to stocks?
- What strategies seem promising to shift the USA towards a path of higher sustainability?

Methodology

- The MISO-model (**M**aterial **I**nputs **S**tocks and **O**utputs), a dynamic inflow-driven stock-flow modeling approach; comparisons of results with databases and the literature.

Data

- National and international databases (USGS, EIA, EPA, FHA, NAPA; CDIAC, Cembureau, FAOSTAT, IEA, Maddison Project, Plastics Europe, UN Comtrade, UNEP, UNSD, WSA, etc.), ew-MFA accounting guides, academic papers and other information (e.g. reports, historical documents).

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Results

- Material stocks of the USA increased 160-fold from 0.6 Gt in 1870 to 96 Gt in 2017. In 1870 and 2017 stocks were predominantly biomass (64 %) and non-metallic minerals (90 %), respectively.
- About 35 % of all materials consumed in the USA (1.9 Gt/year) were used for building and maintaining stocks in 2017 (excl. materials for energy provision needed to produce, use and dispose stocks).
- About 67 % of primary energy consumption (69 EJ/year) in the USA was used for providing services from stocks in 2017, which contributes 55 % to the GHG emissions of the USA (3.6 Gt CO₂-eq./year).
- Compared to the share of the USA in the global population (4 %), its shares in global material stocks (10 %), primary energy consumption (17 %) and GHG emissions (13 %) are overproportionally high.
- The energy and carbon intensities of stocks have strongly declined from 1949 to 2017 which has resulted in a long-term relative decoupling of stocks, energy and CO₂ emissions. Further stock efficiency improvements alone, however, are likely insufficient to keep global warming below 1.5°C.
- Stocks potentially need to be reduced, transformed and redistributed to ensure both a sufficient level of services and ecological sustainability. The USA therefore requires a transformation towards new patterns of production (e.g. circular economy) as well as service-provisioning (e.g. public transport).
- Future research can contribute to changes in stock use- and production patterns by linking stocks and flows to services and exploring biophysically meaningful pathways to sustainability transformations.

Target Audience

- Scientists and Students in Social- and Industrial Ecology, Ecological Economics, Environmental History and other Sustainability Sciences, NGOs, International Organisations, Decision and Policy Makers.