Feature

A New Era of Economic Measurement for the Environment and Natural Capital

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Introduction

National economic statistics inform evidence-based decision-making, offer insights about relationships within a society, and provide the scorecard that political decision makers use to set goals and evaluate economic progress. The omission of environmental service flows, such as water and air purification, from production and income accounts and the omission of natural capital stocks, such as land, forests, minerals, and fish, from balance sheets have been recognized as an important gap in economic statistics for at least 50 years. The need to include natural capital and the environment in national economic statistics has never been greater, because society is attempting novel economic solutions to new challenges that link the economy with the environment.

National economic statistics are a foundation for narratives about "progress," yet the current national income and product accounts, and associated summaries (e.g., gross domestic product [GDP]), miss important features of economic welfare—by design. Fisher (1906); Nordhaus and Tobin (1972); Solow (1974); Nordhaus and Kokkelenberg (1999); Stiglitz, Sen, and Fitoussi (2010); Dasgupta (2021); and Diewert (1992) establish the theoretical links between changes in welfare and changes in the environment and connect them with national economic accounts (Brandon et al. [2021] provide an additional review). Environmental economics has always led in this area, illustrated by the fact that the very first articles published in two of the leading environmental economics journals address this topic (Maler 1991; Fenichel and Abbott 2014).

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National statistics feed growth forecasts and policy decisions related to business cycle dynamics, price stability, labor, and fiscal and monetary policy (e.g., Brunetti et al. 2021). However, environmental processes, including climate change, also affect the macroeconomy (CEA 2023). Changes in natural capital influence economic concerns such as labor supply, real interest rates, and long-term growth. The connections between the growth of production and social welfare have received substantial attention, and authors often assume that natural capital or environmental services are part of the measurement system or call for their inclusion (Weitzman 1976; Hamilton and Clemens 1999; Dasgupta 2001; Sefton and Weale 2006).

The United States is embarking on an industrial policy approach to address climate change and sustainable development. However, important outcome targets, including climate, are not connected to the existing economic measurement system. The Bipartisan Infrastructure Law and Inflation Reduction Act of 2022 allocated substantial federal spending on restoring and improving natural capital—through expenditures to manage fire and flood risk, for example. However, once the initial sums are spent, in many cases, this wealth vanishes from national accounts and national balance sheets. The environmental improvements will not factor explicitly into growth forecasts unless the new system develops quickly. Secretary of the Treasury Yellen's vision of "modern supply-side economics" can be thought of as focusing on the capital inputs that private markets are ill-suited to supply, including natural capital and environmental quality.

There is progress in measuring the environment in connection with national economic statistics. New data sources and measurement methodologies are emerging (Fenichel, Abbott, and Yun 2018; Bagstad et al. 2020; Wentland et al. 2020; Muller, Fenichel, and Bohman 2024). It is now feasible to include the environment and natural assets in national economic accounts (Jorgenson 2018). The global community is focused on measures that go "beyond GDP." The UN Environment Programme (Managi and Kumar 2018) and the World Bank (Cust et al. 2021) have developed global natural capital accounts as part of wealth accounts. Some researchers are constructing data sets that mimic some features of natural capital or environmental-economic accounts using federal microdata (e.g., Shapiro and Walker 2018; Colmer and Voorheis 2024).

The next section of this paper provides a brief description of the US national strategy to develop natural capital accounts and environmental-economic statistics. Then the paper discusses how the new statistics can be used. The penultimate section outlines research opportunities. The final section concludes.

Description of US National Strategy

Statistics for Environmental-Economic Decisions (OSTP, OMB, and DOC 2023; "the national strategy") is a 15-year program, initiated in 2023, to develop natural capital accounts and environmental-economic statistics to the point of routine, official US government statistics (as opposed to research outputs, which are unofficial).[1] The national strategy goes beyond past US federal agency-led projects, many of which helped lay the intellectual

[1]https://www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf.

groundwork for the national strategy.[2] The national strategy, which went through a public comment process, demonstrates demand from political leadership. It was signed by three cabinet secretaries and provides clear direction from the White House to the federal government, grounded in existing legal authorities. It was accompanied by a specific request in President Biden's 2024 budget.[3]

The national strategy motivates the development of a system of environmental-economic accounts, positions the system in the global context, explains connections to existing national economic accounts, lays out a development plan, and specifies administration. These five areas are addressed in the form of principle recommendations, each with numerous supporting recommendations.

The first recommendation is to be pragmatic and provide information to guide decision-making in multiple contexts. For sustainable development, it is important to measure current production (e.g., GDP) and the wealth that creates future production opportunities that depend in part on natural capital. The World Bank's Changing Wealth of Nations report (Cust et al. 2021) suggests that US natural capital wealth began declining around 2010, even as GDP continued to rise. Executive Order 14030 (2021) instructed the federal government to consider how climate change affects the federal budget. While GDP is a core input into the federal budget forecast, at present it does not account for climate change. A national set of environmental-economic statistics will make it easier to adjust economic forecasts of production that are useful for forecasting tax revenue (Muller 2014; CEA 2023). The need for such adjustments to refine long-term budget forecasts does not stop with climate change; water, biodiversity, land, minerals, and forests have potentially strong effects on future production. Data from natural capital accounts may also influence business and conservation decision-making.

The second recommendation is to ensure consistent measurement of changing US wealth over time, as well as international harmonization. Domestic comparability has implications for translating the breadth of environmental valuation into useful statistics. Furthermore, there is a challenge of meeting high intellectual standards while supporting countries around the world to do the same.

The third recommendation is that natural capital accounts and environmental-economic statistics should be embedded in the system of national economic accounts. The national strategy makes three supporting recommendations. First, the system should be guided by international standards from the System of National Accounts (SNA; European Commission et al. 2009) and the System of Environmental-Economic Accounts (United Nations et al. 2014, 2021). Paragraph 1.46 of the SNA (European Commission et al. 2009) states that "many environmental assets are included within the SNA" as nonfinancial, nonproduced assets. However, currently few countries complete these sections of the accounts. The second supporting recommendation is that the natural capital accounts and environmental-economic statistics should be produced according to a small number of specific accounting boundaries (e.g., three) and should be organized into a set of workable classification systems that align, to the extent possible, with existing classification systems (e.g., the North American Industrial

[2]The national strategy includes an appendix on the history and relationship to prior US government efforts.
[3]https://www.whitehouse.gov/wp-content/uploads/2023/03/budget_fy2024.pdf.

Classification System [NAICS] or North American Product Classification System [NAPCS]).[4] Accounting boundaries define what counts and what does not. From a welfare economics perspective, these implicitly create a social welfare function. However, they are necessary to develop a time series of statistics that does not depend on specific policy interventions. The national strategy suggests partitioning boundaries around (1) the existing SNA boundary, (2) a boundary that accounts for defensive expenditures (a long-time concern in national accounting; Coyle 2015), and (3) a household-produced services boundary.[5] The third supporting recommendation is to use the best available economics and science.

The fourth recommendation is to use a 15-year phased approach, enabling some sections of the system to develop sooner. The first phase includes accounts for air emissions, water, land, environmental activities, and marine systems, as well as development of classification systems, data-sharing protocols, valuation standards, and other summaries and tools. The second phase includes minerals and energy, forests, urban green space, pollinators, and further development of the marine accounts, along with guidance on the connections between the natural capital accounts and benefit–cost analysis and precursors to including changes in natural capital within net domestic product and income. Along with the phased approach, the fourth recommendation also includes developing a change-in-natural-asset wealth metric, as suggested by Arrow et al. (2004), and developing dashboards to communicate physical and monetary changes, following Stiglitz, Sen, and Fitoussi (2010).

The fifth recommendation is to use existing authorities and expertise to develop, and update on a regular basis, the natural capital accounts and environmental-economic statistics. The national strategy uses the authorities of the Chief Statistician of the United States,[6] as defined in the Paperwork Reduction Act of 1995 and Evidence-Based Policymaking Act of 2018.[7] The latter calls for statistics related to "the economy, society, [. . . and] the natural environment."

Use Cases

By providing measurements that complement GDP, natural capital accounts and environmental-economic statistics shape conversations about socioeconomic progress and sustainability. This is perhaps their highest profile use: "GDP is often taken as a measure of welfare, but the SNA makes no claim that this is so and indeed there are several conventions in the

[4]https://www.census.gov/naics/.

[5]Paragraph 1.41 (European Commission et al. 2009) acknowledges that household-produced services are "productive in an economic sense" but argues "they have little relevance for the analysis of inflation or deflation or other disequilibria within the economy. The inclusion of large nonmonetary flows of this kind in the accounts together with monetary flows can obscure what is happening in markets and reduce the analytic usefulness of the data."

[6]This office, within the Office of Management and Budgets, coordinates the statistical system.

[7]Both acts passed after the Bureau of Economic Analysis (BEA) initiated environmental-economic accounting in 1992. In 1994, Congress directed the BEA to suspend work pending an independent review. The review was published as "Nature's Numbers" (Nordhaus and Kokkelenberg 1999). There have been additional reviews including those by the National Research Council (2005) and the US Government Accountability Office (2007).

SNA that argue against the welfare interpretation of the accounts" (European Commission et al. 2009, para. 1.75).[8]

To develop an interpretation about human welfare, consider a society that produces output (GDP) in each time period. The output is "liquid," meaning the society can easily choose to consume, invest, or tax that output after it is produced. Output is produced with inputs. These include produced and financial capital measured in the SNA; natural capital, some of which is, and some of which is not, measured in the SNA in principle (though seldom is any measured in practice); and human capital or labor, which is not measured in the SNA. A government concerned with social welfare is interested in the discounted value of a welfare index that measures liquid and nonliquid output minus consumption. Nonliquid production includes household production, such as caring for one's children, or most outdoor recreation. Nonliquid production is not covered by the SNA.

Another relevant category is defensive expenditures, which also are excluded from GDP. Defensive expenditure is where people allocate resources to protect against risks, including environmental risks, or to reduce costs. For instance, someone may acquire clean water either by protecting a watershed or by buying a bottle of water. In this case, the defensive expenditure problem is that the water purification service of the forest is omitted from the GDP, whereas the defensive expenditure on water is included. This means that forest is not treated the same way as a water purification plant, even if they provide the same service—though perhaps the forest does so at a much lower cost.

Because GDP excludes nonliquid production, and fails to treat defensive expenditures as intermediate inputs, GDP misses vital components of socioeconomic progress. Arrow et al. (2004) show that, under standard assumptions, a change in welfare is proportional to the change in real (as opposed to nominal) wealth of capital stocks evaluated at appropriate, constant, accounting prices, represented as changes in the balance sheet, when the balance sheet is sufficiently comprehensive so that it covers capital inputs for liquid and nonliquid production. Such an approach provides a clear path to "beyond GDP" measurement.

There are many nonwelfare uses for the accounts. Natural assets within SNA are relevant for medium-term national budget forecasting, including fish stocks, land, and forests. Assets that currently are within the SNA, along with those outside the SNA that reduce defensive expenditures, are important for longer-term forecasts. Experience with childcare and COVID-19 suggests that summing across all three accounting boundaries is important for labor market forecasts. Budget and monetary policy forecasts depend on forecasts of liquid production, suggesting that omitting natural capital would at best imply mismeasurement of productivity associated with omitted variables. The implications of such errors for price stability, total factor productivity, interest rates, debt ratings, bonds, and other macroeconomic quantities are just starting to be investigated (Brandt, Schreyer, and Zipperer 2017; Bastien-Olvera and Moore 2021; Muller 2021; Agarwala et al. 2022; Rizzi 2022; Goldsmith-Pinkham et al. 2023).

[8]However, the draft 2025 revisions to the System of National Accounts guidance discuss how the accounts could be used to assess changing well-being and sustainability (https://unstats.un.org/unsd/nationalaccount/RAdocs/Draft_2025SNA.pdf).

There are additional possible uses for environmental-economic statistics. For example, national environmental-economic statistics could support environmental, social, and governance (ESG) benchmarking by connecting environmental dependence and impacts via established industrial classification systems. Furthermore, the classification systems and taxonomies could help refine the plethora of ESG-related classification schemes (Berg, Koelbel, and Rigobon 2022).[9] The environmental-economic accounts will likely be important for regional economic planning models that pull heavily from national statistics for setting parameters. A national set of environmental-economic statistics could be helpful for benchmarking environmentally linked trade policies.

Research Opportunities

National natural capital accounts and environmental-economic statistics will open new pathways for research and will depend on academic contributions.

First, there is an opportunity to clarify the relationship between accounting and benefit–cost analysis. The academic literature's focus on national accounts and "social benefit–cost analysis" has led to confusion. Benefit–cost analysis is a forward-looking assessment of the trade-off associated with potential alternative decisions. National accounts provide an after-the-fact record of how production, income, opportunities, and, potentially, welfare have changed. The fact that GDP and other national accounting summaries are forecasted and used in benefit–cost analysis adds to the confusion. Both forms of analysis require scoping and a set of guiding principles. Table 1 outlines key features that distinguish national accounting from benefit–cost analysis. Many differences are rooted in the role of decisions and counterfactual scenarios in benefit–cost analysis, compared with data collection and organization of national accounts.

Second, the national strategy identifies valuation standards as an unresolved question. Most nonmarket valuation evolved in the context of benefit–cost analysis, which is focused on welfare (Phaneuf and Requate 2017), rather than adherence to accounting boundaries developed through a deliberative process. The focus on surplus measures rather than (implicit) prices confuses the accounting community, despite the fact that recovering demand curves—the quantity-dependent marginal value at which goods are exchanged—is a core element of measuring the marginal value of nonmarketed goods and services. Research could adapt existing methods to align with the accounting boundaries and classification systems (recommendation 3). An important question is how to adapt valuation methods for use in the national accounting context.

It is also important to revisit index numbers (Diewert 1992; Dumagan 2002; Banzhaf 2005) to reflect simultaneous changes in quantity and relative scarcity of natural capital when liquid and nonliquid production and "consumption" are important. National accounting often starts with nominal measures, whereas environmental economics often focuses on real measures. Converting between the two is important. Index number theory helps bridge the divide between welfare assessments and national accounting concepts.

[9]Environmental, social, and governance reporting, auditing, and rating regimes evolved from corporate social responsibility (CSR).

Table 1 Comparison of the features of benefit-cost analysis and national accounting

Benefit-cost analysis	National accounting
Clear goal and specific intervention or decision	General and multiple use
Requires a counterfactual, a "with and without" specific decision. Counterfactuals are by definition hypothetical, which are never observed *ex post*.	Only what is observed is included. Decisions are not included, and there are no comparisons with unobserved counterfactuals.
What data are critical to include can be simplified and customized based on the intervention or decision being considered.	There is no opportunity to simplify which data are included, so the details of the broad set of priorities, principles, and practical limitations are often at the fore.
Replicability over time is less important once the decision is made.	Repeat measurement over time is the purpose.
Takes everything else as constant (partial equilibrium).	Observes what happened (general equilibrium).
Environmental economists have a lot of experience with the relevant policy questions.	Environmental economists have less experience with the policy questions where national accounts are traditionally used.

Third, national accounts measures need to be scalable and replicable while spanning the nation. Few nonmarket valuation studies cover the entire country or are easily repeatable year over year. An important academic contribution is to consider how nonmarket demand for environmental goods and services or changes in the value of natural assets can be produced repeatedly at scale. Space-based satellite data, in-situ sensors, smart phones, and increasingly richer administrative data are starting to put these scaling challenges within reach. Making repeatable measurements still needs to be demonstrated.

Fourth, building economists' and national accountants' joint understanding of valuation standards along with scalability may raise challenges similar to those that need to be addressed in the process of transferring valuations from one context to another—a process known as *benefits transfer* in the benefit–cost analysis literature. It is important to ask what can be learned from the literature on benefits transfer (Johnston et al. 2021) to complete national natural capital accounts or other environmental-economic statistical series. Advances in the study of benefits transfer may also provide insights in how to bridge national accounting data with benefit–cost analyses.

Fifth, academic economists must begin developing applications that extend beyond welfare analysis. Bastien-Olvera and Moore (2021) attempt to reflect natural capital in productivity estimates. It is important that policy officials can see how the accounts are useful for "day-to-day" tasks in addition to use as a scorecard. Thus, it is critical that economists begin showing how the accounts can improve decision-making.

Many of the research needs and challenges related to environmental-economic accounts are not unique. The bar for environmental-economic statistics should be no different from for other sectors of the economy. The challenges of including the environment and digital economy in national accounts are surprisingly similar. These include addressing "free" services and capital lacking a legal owner (Brynjolfsson et al. 2019). Given the clear understanding that the digital economy should be included in the economic measurement system, these similarities create opportunities for learning and windows to address skepticism about the importance of natural assets contributing to the economy.

Conclusions

The United States is embarking on natural capital accounting and environmental-economic statistics with the rest of the world. The G7 Climate Energy and Environment Ministers (2023) affirmed, "We are working to include environmental-economic statistics and natural capital accountings [sic] in our core national economic statistics." The full-scale development of these statistics will do three things. It will change the relationship between the environment and economic policy by moving economic environmental analysis and policy concerns beyond benefit–cost analysis. This requires environmental economists to consider economic endpoints beyond consumer welfare. Second, these statistics will open new opportunities for economic research on the environment and environmental research on the economy in ways we cannot yet fully appreciate. Third, these statistics promote the interdisciplinary nature of economic research around the environment and require input from the academic community to contribute to solving practical challenges. This effort will be worth it to usher in a new era of economic measurement first envisioned over 100 years ago.

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