Jointly Determined Economic and Ecosystem Service Values in General Equilibrium

Travis Warziniack (corresponding author, USDA Forest Service, travis.w.warziniack@usda.gov); Kenneth Bagstad (U.S. Geological Survey); Clyde F. Casey (U.S. Geological Survey); Christopher Mihiar (USDA Forest Service); Charles Rhodes (U.S. Geological Survey); Christopher Sichko (USDA Economic Research Service)

This paper develops methods for constructing asset accounts for ecosystem services from forests consistent with standards in the UN System of Environmental-Economic Accounting (SEEA). We explore the potential for these accounts to be used in general equilibrium models to assess impacts of public investments when markets are tightly integrated with ecosystem services. The accounts and models are developed around a case study on US national forests, where critical tradeoffs exist between provision of economic products (e.g., timber, fodder, water) and other ecosystem services (e.g., carbon storage, water quality regulation, recreation).

This work overcomes past data limitations by paring recently developed US ecosystem accounts with long-term plot-level data on forest ecosystem services. Building on the growing natural capital accounting literature (Bagstad et al. 2021), we use SEEA standards to formulate regional natural capital accounts across national forests using USFS Forest Inventory and Analysis (FIA) data. As in other national accounting systems, time series data are needed to measure the flow of services and calculate relative value shares for built capital, labor, and natural capital. In the case of ecosystem services, time series data are also needed to calculate the landscape capacity to reliably produce ecosystem services (Hein et al. 2016). FIA data include forest and vegetation extent, volume, ownership, and removal rates on all US lands, dating back to 1930. We anticipate using FIA data to create natural capital accounts for timber provisioning, grazed biomass, crop pollination, water supply, and climate regulation (carbon sequestration).

These accounts will then be used to construct general equilibrium models, which will allow us to demonstrate paths for valuing ecosystem services at the national scale in a manner compliant with SEEA and the System of National Accounts. A major limitation of general equilibrium models in natural resource economics has been their neglect of the nonmarket side of the economy. Environmental impacts in most general equilibrium models occur outside the model or through separable effects on utility. The first approach assumes an unrealistic structural break between economic behavior and environmental quality. The second allows environmental quality to affect welfare but not commodity demands, and thus prices, for other goods in the economy. All approaches to date leave the value or price of nonmarket components of the good fixed; so, while all other prices adjust to obtain a market equilibrium, previous studies neither allowed such adjustments for environmental goods nor recognized that willingness to pay (i.e., the market clearing price) is fundamentally an equilibrium concept (Warziniack et al. 2017).

Fully integrating ecosystem services into accounting systems is important to accurately decompose factor productivity shocks across built and natural capital and evaluate tradeoffs between investments in natural capital and other forms of wealth. It enables measurement and

monitoring of ecosystem service values over time using standard economic theory. Since economic and environmental systems are jointly determined, shadow values for ecosystem services adjust following changes in the economic system (Crocker and Shogren 1999, Fenichel, et al. 2018), and sustainability requires that built, natural, and other capital investments offset net depreciation and degradation to maintain total factor productivity in the economy (Polasky et al. 2015). The structure of general equilibrium models allows us to estimate managers' implied values of ecosystem services, essentially calibrating the model to recover shadow values for natural capital over time. Hashida and Fenichel (2021) similarly use an asset pricing model for natural capital on managed forests. They focus, however, on a single ecosystem good (timber) and only account for other uses through aggregate passive or nonuse value associated with standing trees. In the case of public lands, and especially national forests, multiple uses are of the greatest interest.

Our case study of US national forest and grasslands is ideal for addressing these issues. As of this year, federal accounting standards separate public lands into working, conservation, and operational lands. This has implications for natural capital valuation, since technologies to optimize one or more services from the capital are relevant for operational and working lands. Acknowledging the complexity of this, the Federal Accounting Standards Advisory Board agreed to continue discussing the possibility of reporting the valuation of public lands, while continuing to report acreage across the three categories as a proxy for value. We anticipate using these methods to quantify impacts from timber harvests, fuels management for wildfire, and natural climate solutions.

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