Comment: "Natural Capital Accounting on Forest Lands in the United States: An Application to the Colorado River Basin" by Warziniack et. al.

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Natural capital enables the production of market goods and services and the provision of non-market services that benefit, and sometimes are critical to, individuals' welfare. The United States is beginning to craft national accounts that track the stock of natural assets and their marginal values (*i.e.,* price), following the UN-SEEA (United Nations et al. 2014; United Nations Statistical Commission 2021). Once populated, these accounts enable the calculation of exchange values, which are a good's price multiplied by its quantity. The difference in these exchange values through time will inform if an asset is being managed to achieve sustainable development because changes in exchange value approximate changes in welfare (Arrow, Dasgupta, and Mäler 2003). Sustainable development is non-declining welfare for future generations (World Commission on Environment and Development 1987).

William Nordhaus identified "the big five" of natural capital accounting as forest, soil, water, clean air, and climate (Nordhaus 2023). Mismanagement of these resources may seriously hinder sustainable development. Therefore, estimating these stocks and their values is pressing. These natural assets are in Phase I or II of the National Strategy (Office of Science and Technology Policy, Office of Management and Budget, and Department of Commerce 2023).

Warziniack et al. (2024) significantly contribute to the field by demonstrating methods that can lead to the population of forest natural capital accounts, one of "the big five." They apply their methods at a substantial scale, estimating the stock of forest land and the cost of deforestation expected under projected management of the Upper Colorado River Basin (UCRB). Thirty million people live in the UCRB, nearly 10 percent of the United States population.

Warziniack et al. (2024) use the U.S. Forest Service Forest Inventory Analysis to determine the current stock of forests and carbon storage. They use the U.S. Environmental Protection Agency's Integrated Climate and Land-Use Scenarios (ICLUS) for their modeled land-use changes. Land-use changes are based on the International Panel on Climate Change projections. This demonstrates how federal agency data that has already been collected can be used to populate the national accounts.

Warziniack et al. (2024) use a computable general equilibrium (CGE) model to estimate the benefits that forests provide through timber production, water purification, and carbon storage. The cost of deforestation is calculated by comparing deforestation projections from ICLUS to a counterfactual scenario where the stock of forest in the UCRB remains at its 2018 acreage.

By using a general equilibrium model, their estimated cost of deforestation considers forests' complements and substitutes. This consideration is critical for the correct valuation of natural resources that are enabling assets to market goods and those that have produced substitutes. Partial equilibrium results can be appropriate when the benefit of an ecosystem is only local (*e.g.,* endangered species (Maher et al. 2020)).

Warziniack et al. (2024) predict that 327.5 thousand acres of forest in the UCRB will be lost to development by 2100. In 2018, there were 93 million acres. The present-value cost of total deforestation in 2100, compared to 2018 acreage, is $30.24 million. This result assumes deforestation will happen at a constant rate. The undiscounted cost of this loss of forest land is $76.5 million, which is a relevant upper bound if deforestation happens quicker than a constant rate.

Most of the cost of deforestation comes from losing carbon storage. This loss leads to a $28 million cost, which dominates the loss of timber production ($2.15 million) and water purification ($90,000). If concern follows costs, the primary concern about deforestation in the UCRB should be its implication on climate change. Future management policies should consider how the loss from carbon storage dominates the loss of timber products while bearing in mind that the social costs of carbon are global and the cost to the timber industry will be felt the most by local communities.

The small cost of deforestation on water purification in the UCRB should not be extrapolated to other regions. This emphasizes why a significant contribution of Warziniack et al. (2024) is methodological. The significant amount of public land in the UCRB decreases the cost of deforestation in the UCRB on water purification. More research is needed in other regions with different mixes of private and public forests, particularly the southeastern U.S., which has a high share of private forests that are being deforested quickly.

It is important to consider how the results from benefit-cost analyses can overlap or differ from core statistics for the national accounts. Benefit-cost analyses compare one state of the world to a policy-relevant counterfactual. The results in Warziniack et al. (2024) come from a benefit-cost analysis comparing projected deforestation to a counterfactual where forest acreage stays at its 2018 level at zero cost. Accountants calculate changes in exchange value. As mentioned, exchange value is the price of an asset multiplied by its quantity. Accountants evaluate if an asset is being managed sustainably by comparing the exchange value in one period to a prior one. In the case of Warziniack et al. (2024), their counterfactual scenario is the same as the scenario accountants consider because they compare projected changes to the initial time period. This equivalence will not be valid for all benefit-cost analyses because it relies on the benefit-cost analysis's counterfactual to be the state of the world in the initial period at zero cost.

It is also important to highlight that the national accounts will require price-quantity pairs for environmental assets to calculate exchange values. Warziniack et al. (2024) did not report a price, or marginal value, for an acre of lost forest in the UCRB. However, because their counterfactual is equivalent to the scenarios considered by accounts, I can calculate the average value for a lost acre of forest when I make the simplifying assumption that price is exogenous to quantity and that average value is a good approximation for marginal value. Both assumptions are common when populating national accounts.

Assuming a constant marginal value and a linear decline in forest acreage as Warziniack et al. (2024) do, the change in exchange value between time-period 0 and T is

$$\Delta EV = \sum_{0}^{T} \left(\frac{1}{1+r} \right)^{t} * p * \Delta x_{t},$$

where p is the marginal value of one acre of forest, r is the discount rate, Δx is the change in the stock of forests, t is the period, the initial time-period is 2018 and T is 82 (the year 2100). The change in equivalent variation from 2018 to 2100 is equivalent to the cost of deforestation from Warziniack et al. (2024), $30.24 million. The annual change in forest coverage is constant, and about 4,000 acres per year. The discount rate is 2.25.

I find that the results in Warziniack et al. (2024) imply that the marginal value of one acre of forest is $220.22 by solving for p.[1] This assumes that price is exogenous to the stock of forest, which should not be assumed if changes in the stock are large. The change in forest acreage projected by Warziniack et al. (2024) is less than one percent.

Finally, as Warziniack et al. (2024) discussed, using a CGE model prompts the conversation of what other services associated with forests have been left out and what assumptions are appropriate. This is a useful contribution to the field because future research can modify and build on their CGE model. An assumption worth relaxing may be that carbon lost from losing a stock of trees is lost forever because durable wood products can store carbon (Domke et al. 2020). Additional ecosystem services from forests identified by Warziniack et al. (2024) are recreation and air purification. Additional services of interest to Phase II of the National Strategy are how forests cool urban areas and stabilize soils (Office of Science and Technology Policy, Office of Management and Budget, and Department of Commerce 2023). Soil stabilization is partially captured by the value forests provide to water purification.

References

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[1] Assuming a constant percent change (-0.00425%) leads to nearly the same result, $200.12 per acre lost.

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