The Social Costs of Nutrient Pollution in the United States

Tihitina Andarge, Yongjie Ji, David A. Keiser, Catherine L. Kling, Daniel J. Phaneuf, Yau-Huo Shr*

Abstract

The United States has spent approximately $5 trillion on efforts to improve surface and drinking water quality since 1970 (Keiser and Shapiro 2019). Yet, the social costs of water pollution remain poorly understood. There have been only limited efforts to recover benefit estimates of national or regional programs, and even fewer that recover estimates of benefits that vary across space (USEPA 2000; Hansen and Ribaudo 2008, Griffiths et al. 2012). This stands in sharp contrast to advancements in the air pollution literature (Keiser and Muller 2017). This paper seeks to fill this gap.

We propose three main innovations to construct a national integrated assessment model (IAM) of nutrient pollution. First, we develop a framework for the construction of the social cost of water pollution that incorporates the spatial variability of damages from pollution. This first step is crucial, as it guides our interpretation of how to aggregate benefits across space and uses of water resources. Second, we develop valuation functions that estimate benefits of water quality improvements for three main categories: housing price impacts, water-based recreation, and drinking water treatment costs. We focus on these categories, as they have served as the predominant measure of benefits in prior literature. Finally, we use local measures of water quality, housing markets, recreation, and drinking water treatment data to estimate spatially-explicit measures of the benefits of water quality improvements across much of the continental U.S.

Our first step develops a theoretical model of consumer behavior that incorporates the multiple pathways through which water quality affects well-being. Specifically, our model is static and based on the assumption that consumers engage in two-stage decision making. First consumers choose their residential location choice based on a set of house and neighborhood attributes. The set of neighborhood attributes includes the distance to an amenity lake and its associated water quality, and access to local drinking water supplies are part of the neighborhood characteristics over which they search. Once they have chosen a neighborhood, households can choose how many recreation visits to sites outside of their neighborhood to visit each year.

We use this model to develop a set of assumptions under which values should be aggregated to generate a total value across space and time. We also use this model to understand empirically how to aggregate estimates of values related to separate uses of water resources to recover total values. To estimate housing market impacts, we conduct a meta-analysis to understand how nutrient pollution impacts housing values. Further, to estimate recreational benefits, we rely on a

* Andarge and Keiser (UMass Amherst); Ji (Iowa State); Kling (Cornell); Phaneuf (Wisconsin); Shr (National Taiwan University). Corresponding author: Keiser (dkeiser@umass.edu).

recent study that links water-based recreational use to nutrient pollution across the US (Keiser 2019) and a large literature that estimates the value of a water-based recreational day. Last, we utilize a recent study that links nitrogen pollution to drinking water treatment costs (Mosheim and Ribaudo 2017), and explore the possible link between phosphorus and these costs (Heberling et al. 2015).

Finally, we calibrate these benefit functions using spatially-refined measures of water quality, housing values, recreation, and drinking water treatment plants across the continental US. This involves predicting baseline water quality levels of nutrient pollution based on a number of sources that provide measures of water quality in individual lakes, rivers, and streams. We also utilize census tract information on housing units and values from the US Census, county-level recreational data from the USDA's National Survey on Recreation and the Environment, and intake and service location data from the US EPA to estimate drinking water treatment costs.

Preliminary results suggest large and important impacts of nutrient pollution across the U.S. Social costs are higher on the coasts and in urban areas, reflecting the importance of population in determining total damages. Ongoing efforts seek to better understand this variation in damages and the sensitivity of the results to assumptions regarding the extent of the market and the relationships that link nutrients to damages.

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