

RESEARCH BRIEF

Unaccounted-for changes in land use, climate, and agriculture undermine efforts to improve water quality

Summary

Long-term changes in land use, agriculture, and climate, which are often unaccounted for in models and management practices to reduce nutrient pollution in surface waters, are undermining efforts to improve water quality. To achieve water quality goals, policy and management will need to address these shifting drivers in goal setting, program design, and evaluation. This may require more transformative thinking and interventions.

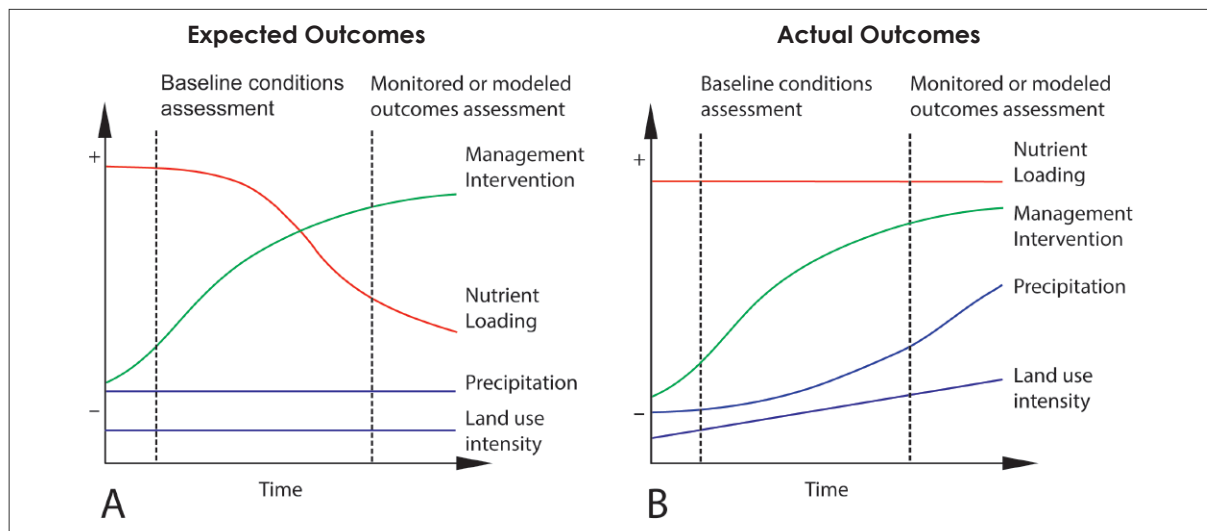
Background

Despite decades of effort, government-led and collaborative initiatives to improve surface water quality in Wisconsin's Yahara River Watershed, a region exemplary of urbanizing agricultural watersheds across the world, have failed to reach their goals. Efforts to reduce nutrient pollution, a main cause of poor water quality, traditionally involve using baseline conditions of land use, agriculture,

and climate—leading drivers of water quality—to predict the efficacy of interventions. This means managers assume social and environmental conditions will remain constant over a project's lifespan to allow them to calculate the expected outcomes. Yet, how people develop land, how farmers farm, and what the local climate is like are constantly changing. This study examines the case of the Yahara and shows how these unaccounted-for “shifting drivers” of environmental change undermine local efforts to improve water quality, particularly to reduce phosphorus pollution. More explicitly addressing these drivers may improve strategies and outcomes.

Research Design

Analyses of historical and management data explain the reliance on goals, baselines, and models to design and evaluate water quality improvement programs. A GIS-based analysis of land-use change between 1939 and 2010, and



Efforts expect nutrient loading to decrease with increased intervention, often assuming climate and land use remain constant (A). In actuality, climate and land use are not constant, an oversight that counteracts interventions (B).

analyses of historical agricultural trends and water quality outcomes demonstrate how these shifting drivers impact efforts. Qualitative analyses of policy documents, scientific and management literature, news media, and interviews and workshops with 82 individuals from the government, NGO, agricultural, and citizen sectors contextualize the quantitative data and illustrate the potential governance implications of shifting drivers.

Findings

Land-use change

Four key land use changes have hindered desired water quality outcomes. First, urbanization has shrunk the amount of land available to farmers for manure spreading, thus concentrating manure on less land and increasing the risk of nutrient runoff. Second, urbanization has brought more imperviously paved surfaces and construction sites, which increase runoff and erosion rates. Third, pastures and small grains (e.g., oats) in agricultural areas have been increasingly replaced by row crops, which expose more nutrient-laden soil, making it more prone to erosion. Finally, wetland loss and modification due to both urbanization and agriculture has meant a loss in these ecosystems' capacity to capture nutrients and, thus, help improve water quality.

Agricultural change

Since the early twentieth century, agriculture has increasingly intensified under the pressure to improve efficiency and increase production. The intensification of dairy operations, in particular, has resulted in higher concentrations of phosphorus in the soil. While the number of dairy farms has decreased, average herd size and per-cow milk production—and, thus, per-cow manure production—have increased. Since farmers have less land on which to spread manure due to urban expansion, manure spreading is more concentrated, leaving higher levels of phosphorus in the soil, which can lead to more intense runoff events. The long history of agricultural intensification has left a legacy of high levels of phosphorus in the soil. Given how slowly phosphorus moves through soil and downstream, this build-up will make it difficult to achieve significant phosphorus reductions, even with significant effort.

Climate change

Annual precipitation and the frequency of heavy rainstorms have been on the rise in recent decades, trends that are expected to continue. More and heavier rains can lead to more erosion and runoff of phosphorus-laden soils into tributaries and lakes.

Implications

This study's findings have implications for similar regions globally. Explicitly considering shifting drivers when defining goals for, implementing, and evaluating nutrient-reduction efforts will provide a more accurate understanding of the consequences of interventions and the reasons they fail. A better understanding of these dynamics is important for adapting policies and management appropriately. When shifting drivers lie outside the management scope and confound the effects of interventions, it is difficult to discern between ineffective managers or techniques and a broader failure signifying the need for a radically different approach, thus obscuring how best to adapt and proceed.

One solution is to improve modeling efforts to capture shifting drivers' contributions to predicted water quality outcomes. The use of scenario planning and analysis may also help decision makers examine shifting drivers, generate conversation of possible and desirable outcomes, and explore opportunities for transformative change. Furthermore, managers may need to reconsider and redefine goals and measures of success to account for determinants that lie beyond their direct control.

This study suggests that transformational change is likely needed to achieve water quality improvement. While findings show interventions are having a positive effect—water quality has not gotten worse—they also indicate that relying on best management practices will not be enough. Addressing the underlying drivers of water quality through innovation, adaptation, and transformation may be the only way to expect and achieve significant progress in cleaning up our streams, rivers, and lakes.

Source

Gillon, Sean, Eric G. Booth, and Adena R. Rissman. "Shifting drivers and static baselines in environmental governance: challenges for improving and proving water quality outcomes." *Regional Environmental Change* (2015): 1-17. doi: 10.1007/s10113-015-0787-0

Research sponsor

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Water Sustainability and Climate Project

The Water Sustainability and Climate Project (WSC) at the University of Wisconsin-Madison is an integrated effort to understand how water and the many other benefits people derive from nature could change over time. The five-year project (2011–2016) is focused on the Yahara Watershed in southern Wisconsin and funded by the National Science Foundation. Visit wsc.limnology.wisc.edu.