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Research Paper

# Fragmented water quality governance: Constraints to spatial targeting for nutrient reduction in a Midwestern USA watershed

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## HIGHLIGHTS

- Government level and policy tool impact spatial configurations of policies.
- Water quality policies did not target areas of high phosphorus yield.
- Program, funding, and data constraints impede targeted agricultural conservation.
- Effective policy must recognize the spatial configuration of interventions.

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## ABSTRACT

Spatially targeted interventions improve the effectiveness of environmental policy, but are challenged by implementation constraints and coordination among governments. Spatial targeting research rarely acknowledges the diversity of actors navigating complicated institutional dynamics to deploy environmental policy instruments. We mapped 35 nutrient reduction interventions by federal, state, county, and municipal governments and interviewed 15 policymakers and agency staff in Wisconsin's Yahara Watershed, USA to understand how multilevel governance impacts spatial targeting and implementation of water quality policy. Our Geographic Information System database showed that county governments implemented the most policies, while the state promulgated the most rules, with uneven application of policy interventions across the landscape. Spatial targeting differed between agricultural and non-agricultural policies and by type of tool (land acquisition, direct management, incentive, and regulation). We found a negative correlation between areas of policy intervention and phosphorus yield across government levels ($p < 0.001$), with the strongest negative correlations by implementing agency. Interviews revealed that for government agencies, spatial targeting is constrained by program and funding requirements and data limitations for soil and land use practices. In order to target the highest phosphorus yielding subwatersheds, governments will need to alter the spatial location of their efforts.


## 1. Introduction

Excess loading of nutrients from both point dischargers and non-point landscape sources has led to widespread eutrophication of lakes and rivers, and subsequent ecological degradation around the world (Bennett, Carpenter, & Caraco, 2001; Carpenter et al., 1998; Rabalais et al., 2002; Sharpley et al., 2013; USEPA, 2009).

Spatial targeting analyses – which address the question of where scarce resources should be used to achieve natural resource policy goals (Margules & Pressey, 2000) – have been proposed as a way to prioritize effort for nutrient reduction in watersheds to meet ecological goals (Marinoni, Higgins, Coad, & Navarro Garcia, 2013), and to provide clean drinking water (Randhir, O'Connor, Penner, & Goodwin, 2001). Spatial analyses are also recognized as essential to contemporary policy research (Herrmann & Osinski, 1999; Owen, 2013). The spatial targeting literature has focused largely on protected areas (e.g. Andelman & Fagan, 2000) or selected individual measures, such as those related to agricultural soil conservation practices and riparian buffers for water quality (Qiu & Dosskey, 2012; Yang, Sheng, & Voroney, 2005) or forest management incentive programs (Carver, Thurau, White, & Lazdinis,

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2006). Yet multiple government agencies implementing measures for water quality improvement across a heterogeneous watershed face the challenging task of choosing among a variety of tools and focal areas to address policy goals. There have been few efforts to map diverse, multilevel policy tools. As increased data availability and software capabilities offer new ways of conceptualizing the management of ecological systems, new spatial analysis tools have fundamentally changed the problems environmental policy research can address (Owen, 2013).

Watersheds are managed by a myriad of governmental and non-governmental organizations whose decisions and actions influence ecosystems. In many countries, authority for environmental protection is divided across several levels of government (Newig & Fritsch, 2009). The federalist system of environmental governance in the United States involves multilevel arrangements that are frequently renegotiated and redefined (Glicksman, 2006). Levels of government are likely to have different approaches to spatial targeting because of their unique roles in water quality management. Federal, state, county, and municipal governments make rules and implement public interventions for surface water quality improvement, most notably under the US Department of Agriculture (USDA) Farm Bill programs (Claassen & Horan, 2001), US Environmental Protection Agency (USEPA) Clean Water Act (CWA) (Dowd, Press, & Huertos, 2008), and various state and local pollution reduction programs (Shortle, Ribaudo, Horan, & Blandford, 2012). These agencies deploy diverse policy instruments to achieve varied goals. National-level policies are often standardized and generic, but they can take into account the dynamics of large ecosystems. For instance, the USDA and USEPA have targeted the Gulf of Mexico dead zone by increasing funding for best management practices and requiring state nutrient reduction plans in the Mississippi River Basin (Margerum & Born, 2000). Local programs and policies may lead to better situated outcomes than governance on higher spatial scales (Leach, Pelkey, & Sabatier, 2002). For example, municipalities may tailor urban runoff policies to address a natural area of great local concern. However, local government may have less access to the technical expertise required to translate generic management guidelines to site-specific projects (Rockloff & Moore, 2006). Landscape outcomes in a multilevel environmental governance system range from coordinated resource targeting to fragmented policy application, in the United States and internationally (Cash et al., 2006).

Several categories of conservation tools are available to agencies at all levels of government, including incentive, regulation, acquisition, and direct management (Bengston, Fletcher, & Nelson, 2004; Doremus, 2003). These tools are expected to result in different spatial configurations, with varied impacts on public ability to target resource concerns. Regulations can be applied to blanket areas; incentives apply where landowners or managers voluntarily participate; acquisitions rely on voluntary sale or donation and may target flagship properties; and direct public management occurs largely on public land. Each type of tool has different implications for management and coordination, extent of the landscape impacted, and public buy-in. For example, Langpap (2006) calls for increased use of incentives – as opposed to regulation – to encourage conservation under the US Endangered Species Act. Funding for incentives is limited, however, and may end or shift focus before conservation results can be realized. On the other side of the spectrum, Nie (2008) reminds collaboration-focused researchers of the power of prescriptive regulation and citizen-suit litigation. The "tools approach" to governmental action allows assessment of public interventions by category, though some scholars of public policy contend that agencies' focus on particular tools may obscure fragmented implementation (Salamon & Elliot, 2002). Overall, many organizations are able to effectively leverage several policy tools at once to hedge against uncertainty (Doremus, 2003).

Targeted conservation is particularly challenging for water quality improvement on agricultural lands - the top source of impairment to water bodies in the U.S. (Hall, Christensen, Bramblett, & Hubbert, 2012). Spatial targeting in the agricultural context refers to the implementation of agricultural best management practices, such as cover cropping or conservation tillage, on parcels identified within a region as exporting significant nutrient loads. Most U.S. private land conservation programs rely on incentives to change individual behavior because regulations are unavailable or unpopular for environmental problems in rural areas (Dowd et al., 2008; Dupont, 2010). In a multilevel context, lower levels of government generally allocate federal funds for agricultural incentives, but they must comply with federal rules, even when combined with state and local funds. Despite the large outlay of public money for agricultural cost-sharing, these programs' contribution to measurable improvements in water quality has been disappointing, as they have failed to keep nutrients on farm fields (State-EPA Nutrient Innovations Task Group, 2009).

Numerous studies have investigated multilevel governance, and others spatial targeting, but little research integrates the two. We aim to paint a nuanced picture of where, and with what tools, different levels of government implement water quality policies across a landscape. Specifically, we examined the spatial pattern of interventions by public agencies to improve water quality in a Midwestern, USA watershed. We asked: (1) How do the spatial extent and location of water quality interventions differ by levels of government (federal, state, county, and municipal) and types of conservation tools (land acquisition, direct management, incentive, and regulation)? (2) How well does each government target the subwatersheds of greatest concern for water quality? and (3) What barriers face spatial targeting for water quality protection in the context of multilevel governance?

## 2. Study site

The Yahara Watershed in Dane County, Wisconsin, USA (Fig. 1) has long been scrutinized by scholars and policymakers—the chain of five lakes are the "most studied lakes in the world" and visible from the state capital (Lathrop, 2007). We draw on this concentration of intervention and research to illustrate disconnects in environmental governance even in a highly managed region. At the center of the 1336 $km^2$ watershed is a metropolitan area of approximately 300,000 people, surrounded by agriculture dominated by corn, soybean, and dairy production. Milk is the county's highest grossing commodity.

The dominant water quality issue in the Yahara Watershed is nutrient and sediment loading into the lakes. Algal blooms driven by excess phosphorus were deemed "public enemy number one" by the County Executive (Dane County Land and Water Resources Department, 2010). Nonpoint pollution sources include fertilizer and manure runoff from agricultural fields, urban lawns, roads, and construction sites; point sources include wastewater treatment plants. While both urban and agricultural sources contribute to water quality impairment, agriculture contributes the majority of phosphorus inputs (Strand Associates, 2013, p. 136).

Nutrient reduction governance in the Yahara Watershed targets both urban and rural sources of pollution. The county government dictates certain land use decisions in municipalities, such as sewer extension permissions or county parkland acquisitions. The County Conservation Division is the government office that advises farmers on and signs them up for conservation cost-share programs including those under the USDA Farm Bill (at the time of writing, the Farm Bill was codified as the Food, Conservation, and Energy Act of 2008). At the state level, the Wisconsin Department of Natural Resources (DNR) administers grant programs and makes