

## 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.

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## 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).

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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, Thureau, White, & Lazdinis,

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, Ribaud, 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<sup>2</sup> 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

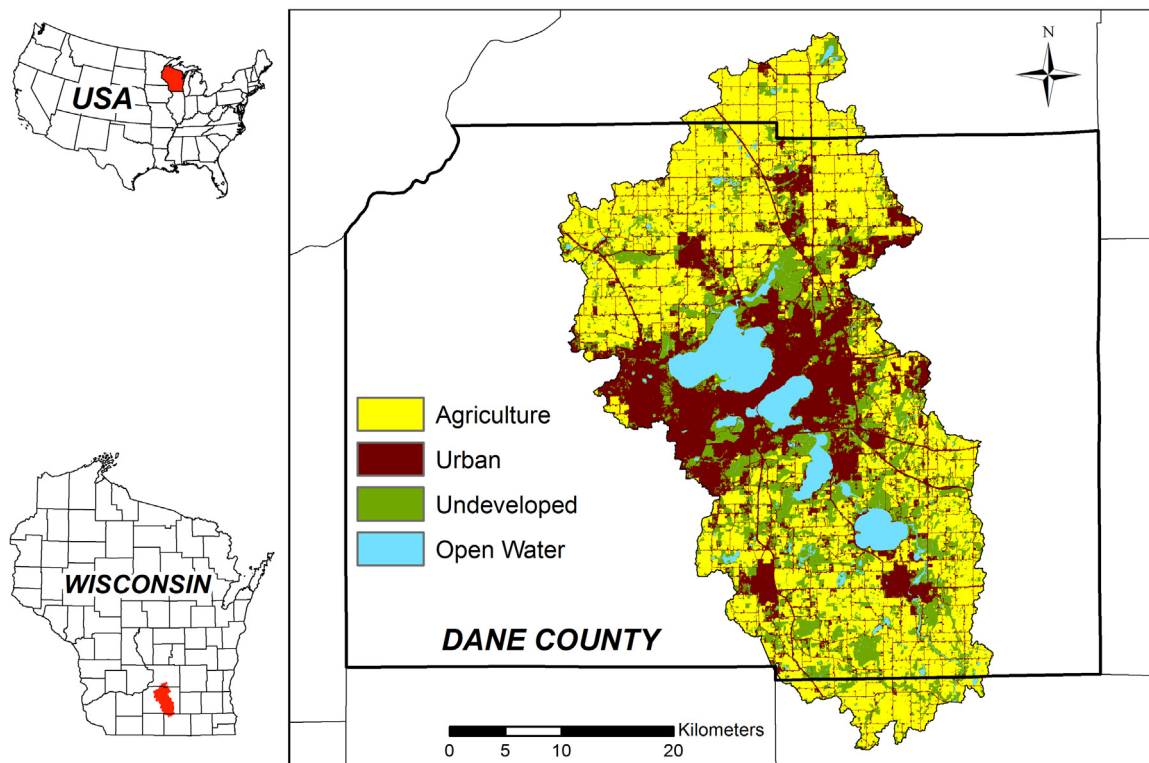


Fig. 1. Location of the Yahara Watershed in southern Wisconsin in the United States; dominant land cover from the 2010 National Land Cover Data.

pollution rules and conservation acquisitions. The DNR is charged with implementation of the Federal CWA National Pollutant Discharge Elimination System (NPDES), which requires permitting of pollution point sources. The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) has jurisdiction over the State's agricultural incentive programs and nutrient management rules.

### 3. Methods

#### 3.1. Spatial policy analysis

We developed a database of water quality interventions by government agencies in the Yahara Watershed (see Appendix A for brief descriptions of interventions, and the Online Supplement for further detail). Interventions were included if they were (a) publicly funded and implemented, (b) land-based, (c) implemented within the 5-year period 2007 to 2012, and (d) aimed to reduce nutrient (phosphorus and nitrogen) and sediment runoff to surface waters as a primary or secondary goal. Our criteria excluded interventions implemented directly in the water. They also excluded work by non-profit watershed groups and for-profit companies.

Interventions were categorized by type of conservation tool: regulation or standard; incentive (grant and cost-share programs); direct management (including public management actions and engineered practices); and acquisition (land conserved through fee simple acquisition or conservation easement). Interventions were next categorized by which government level (or multiple levels) of government were involved in rulemaking and implementation (Table 1). We defined the rulemaking level of government as that which created the standard or wrote the law, and the implementing level of government as that which made field-level decisions, negotiated with landowners, and monitored practices. If the intervention was a grant given to private recipients, the implementing

agencies were considered those that supervised grant implementation.

We mapped policy interventions in ArcGIS (version 10.1). The goal of mapping was to determine the extent and overlap of interventions throughout the watershed and the agency responsible for establishing and implementing the policies. Public acquisitions of conservation land were mapped and categorized by the government level acquiring the parcel or parcels. Incentive programs – grants and cost-share – were mapped for the parcels where the incentive program was applied from 2007 to 2012. For federal Farm Bill conservation programs, for instance, the farm parcels of the cost-share recipients were mapped with publicly available data or by matching recipient names with parcel ownership records. Regulatory programs were mapped according to each statute's definition. For example, Wisconsin's shoreland zoning ordinances were mapped as the area in the 300 m buffer around rivers or streams and 1000 m buffer of lakes or ponds, using the Wisconsin DNR water body base layer. Regulations were represented by specific permit area when permit data were available, such as farms with county winter manure-spreading permits.

Regional water quality experts validated the interventions list and map. Reviewers included a regional planner, two municipal administrators, a commissioner on the County Lakes and Watershed Commission, a County water conservationist, a lawyer for an environmental non-profit, and the director of a Wisconsin soil and water conservation organization. Through this process we added several interventions and clarified the mapping rules. Analyses were conducted on 35 of 41 interventions that could be represented spatially through publicly available data. The most significant unmapped intervention was nutrient management planning, for which the County office did not have spatial data.

We estimated the percent land area covered by each intervention by subwatershed. The Yahara Watershed was divided into 300 subwatersheds based on a recent modeling effort that delineated 200 subwatersheds in the upper Yahara Watershed (Montgomery

**Table 1**

Selected examples of interventions by type of policy tool and government level, separated by rulemaking and implementing agencies.

| Policy tool                | Government level                   |                              |                                                 |                                                               |                                                 |                                                           |                                             |                                       |
|----------------------------|------------------------------------|------------------------------|-------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------|-----------------------------------------------------------|---------------------------------------------|---------------------------------------|
|                            | Rulemaking                         |                              |                                                 |                                                               | Implementing                                    |                                                           |                                             |                                       |
|                            | Federal                            | State                        | County                                          | Municipal                                                     | Federal                                         | State                                                     | County                                      | Municipal                             |
| <b>Acquisition</b>         | US FWS Wetland Management District | Wisconsin state parks        | Streambank protection easements                 | City parks                                                    | Rulemaking and implementing levels are the same |                                                           |                                             |                                       |
| <b>Direct management</b>   | Manure digester                    | Stormwater basins            | Stormwater basins                               | Street sweeping                                               | N/A                                             | N/A                                                       | Manure digester                             | Street sweeping                       |
| <b>Incentive</b>           | US NRCS EQIP                       | WI DNR TRM grant program     | Dane Co. Environmental Council grant            | N/A                                                           | US NRCS CRP                                     | WI DNR Urban Nonpoint Source Storm Water Management grant | WI DNR Lake Classification grant program    | WI DNR Lake Management planning grant |
| <b>Regulation/Standard</b> | CWA NPDES permits                  | CWA 303(d) listing of rivers | Dane Co. nutrient application restriction areas | Municipal Stormwater Ordinances—100 year peak runoff standard | Regulated wetland disturbance                   | Rock River TMDL                                           | Dane Co. phosphorus fertilizer restrictions | Shoreland District permitting         |

Acronyms key: CWA: US Clean Water Act; EQIP: Environmental Quality Incentives Program; FWS: US Fish and Wildlife Service; TMDL: Total Maximum Daily Load; USDA-NRCS: US Department of Agriculture's Natural Resources Conservation Service; WI DNR: Wisconsin Department of Natural Resources

Associates, 2011) and our delineation of 100 comparably-sized sub-watersheds based on a Digital Elevation Model in the lower Yahara Watershed. We then calculated the percentage of each subwatershed covered by each of the 35 interventions. The percentage of land covered by every intervention within a subwatershed was then summed to get a cumulative percent coverage. This ranged from 0 to a possible 3500 for each subwatershed. The total percent intervention coverage is shown in heat maps depicting low to high policy coverage by subwatershed, created in ArcGIS.

We categorized subwatersheds as urban or rural in order to compare coverage of interventions. Subwatersheds were classified as urban if the developed land cover classes were 50% or more of land area, based on 2010 National Land Cover Data, which resulted in 83 urban (28%) and 217 rural (72%) subwatersheds. We conducted a Welch 2-sample *t*-test to determine whether cumulative percent area of interventions differed significantly for urban and rural subwatersheds. The untransformed cumulative percent area data were consistent with assumptions of normality and were not improved by an ArcSin transformation (sometimes used with percentage data), so we report the *t*-test with untransformed data.

We compared intervention locations with total phosphorus yields (kilograms phosphorus per hectare per year) for the 200 subwatersheds modeled for the year 2008 with the Soil and Water Assessment Tool (SWAT). The Montgomery and Associates SWAT model is widely used by policymakers in the watershed. The subwatersheds with the highest nutrient yields are consistent with earlier models and measurements conducted for conservation planning (Lathrop, 2007).

A Pearson product-moment correlation matrix compared interventions with modeled phosphorus yield by subwatershed, calculated in R (version 3.0.1). We correlated phosphorus yields with cumulative percent intervention coverage by municipal, county, state, and federal governments in both their rulemaking and implementation capacities. We also compared the correlation of phosphorus yields with intervention coverage for each type of intervention tool. Interventions were also grouped by whether they targeted agricultural or nonagricultural activities. These correlations give a proxy measure of whether public interventions target areas of concern for watershed nutrient reduction.

### 3.2. Qualitative policymaking and implementation analysis

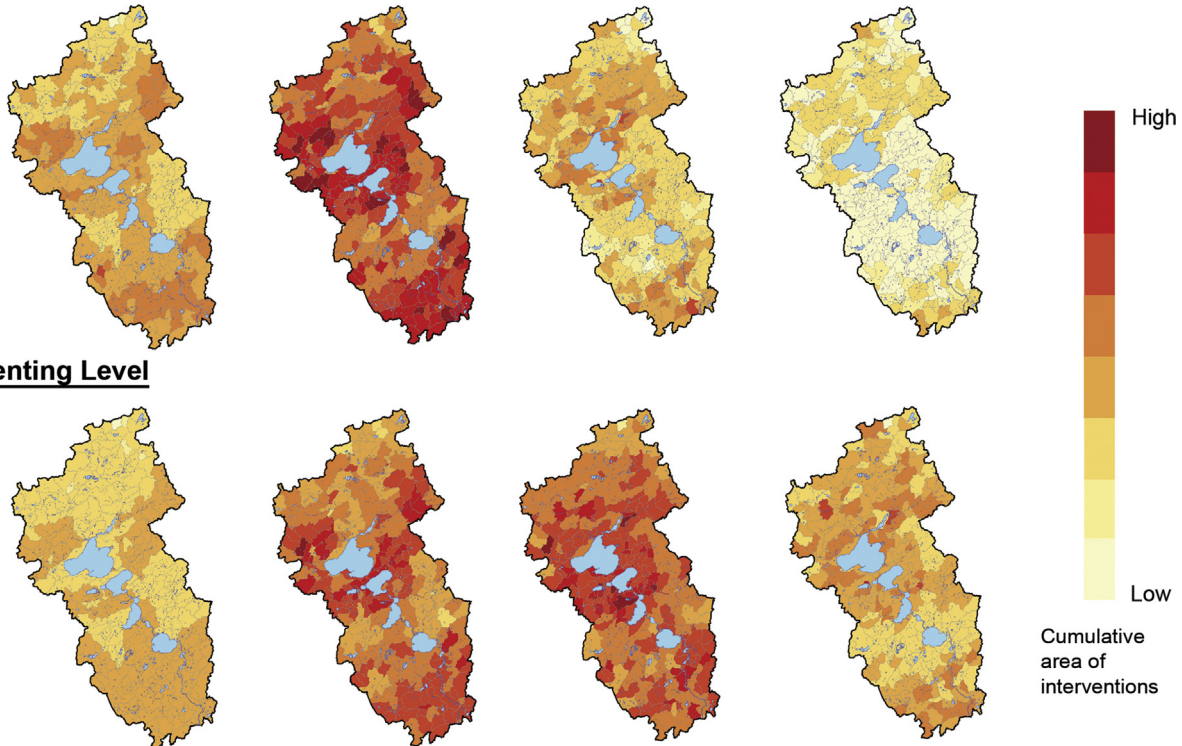
The goal of our qualitative analysis was to investigate the barriers to spatial targeting in the Yahara Watershed. Data sources for qualitative analysis of water quality spatial targeting included policy documents promulgating each of the interventions analyzed ( $n=41$ ), attendance at regional water management-related meetings ( $n=10$ ), and interviews ( $n=15$ ). We focused on barriers to targeting of agricultural land uses since agriculture is the primary source of phosphorus entering surface waters, both locally and in other agricultural watersheds in the U.S. (Hall et al, 2012; Montgomery Associates, 2011). Semi-structured interviews were conducted with municipal, county, and state public officials and NGO representatives ( $n=15$ , which included the interviews to validate the list and mapping of interventions). Interviewees were identified by their role in water quality management and snowball sampling; interviews were recorded and transcribed and qualitative data were analyzed with the software Dedoose (version 4.5) using a grounded theory approach (Charmaz & Belgrave, 2002).

## 4. Results

### 4.1. Spatial configuration of interventions

Spatial configurations of policies differed by level of government in their rulemaking and implementation capacities (Fig. 2). Comparing governments by their rulemaking functions, the state's water quality interventions covered the most area, followed by federal, county, and then municipal governments. The state created the most laws or rules related to nutrient reduction (23 of 35 interventions), closely followed by the county government (14), and federal government (13). The fewest rules were written at the municipal level (6).

While the state led in number and area of rulemaking effort, county government led in implementation. County (24), municipal (16), and state (16) governments implemented the most rules, followed by the federal government (7). The county government also implemented the most interventions by percent area covered, followed by state, municipal, and then federal government.

**Rulemaking Level****Federal****State****County****Municipal****Implementing Level**

**Fig. 2.** Heat maps of interventions by rulemaking and implementing levels indicate the cumulative percent area of interventions for each of the 300 subwatersheds. Darker subwatersheds indicate more intervention coverage.

Spatial distributions of interventions differed by type of tool, with regulatory tools encompassing far more area than incentives, acquisitions, and direct management (Table 2). The concentration of regulations was fairly uniform across subwatersheds, in contrast with the other tools. Direct management interventions by public agencies were primarily in urban subwatersheds while acquisition of land and conservation easements were concentrated in rural areas.

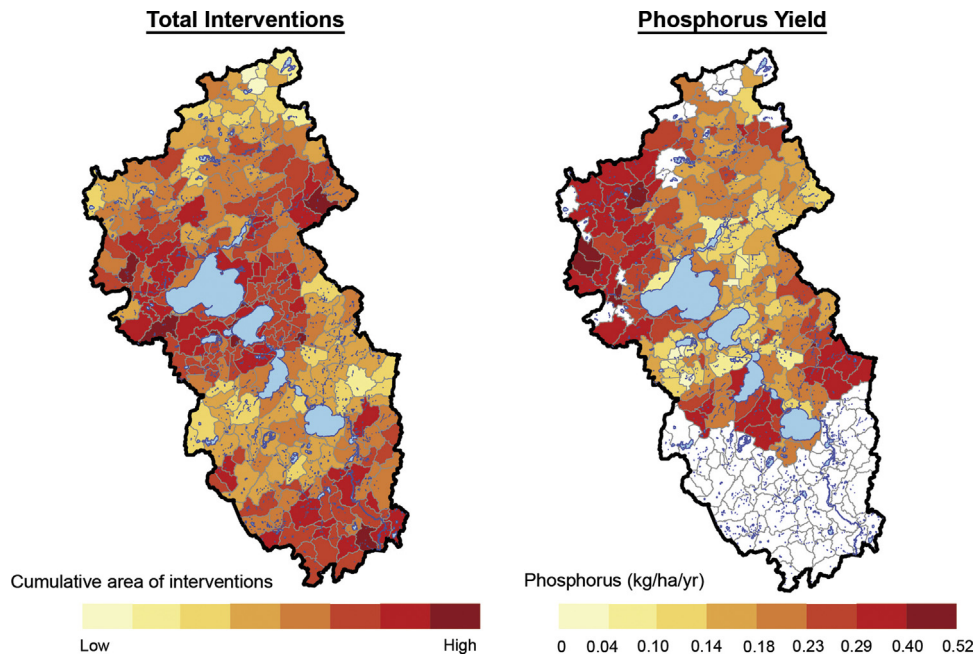
**Table 2**  
Descriptive statistics for correlation analysis comparing cumulative intervention coverage by type of intervention ( $n = 200$  subwatersheds).

| Variable                                                       | Min   | Mean  | Max    |
|----------------------------------------------------------------|-------|-------|--------|
| <b>Phosphorus yield (kg/ha/yr)</b>                             | 0.001 | 0.135 | 0.525  |
| <b>Intervention coverage (cumulative percent area covered)</b> |       |       |        |
| All interventions                                              | 277.8 | 598.3 | 1003.0 |
| Federal rule                                                   | 101.0 | 221.9 | 392.1  |
| State rule                                                     | 226.6 | 456.6 | 764.6  |
| County rule                                                    | 54.75 | 208.0 | 442.5  |
| Municipal rule                                                 | 0.7   | 59.7  | 231.8  |
| Federal implementation                                         | 100.0 | 162.4 | 253.3  |
| State implementation                                           | 161.8 | 388.2 | 612.3  |
| County implementation                                          | 233.0 | 439.9 | 779.8  |
| Municipal implementation                                       | 110.2 | 265.3 | 502.3  |
| Acquisition                                                    | 0.0   | 5.4   | 88.7   |
| Direct management                                              | 0.0   | 10.8  | 70.3   |
| Incentive                                                      | 0.0   | 15.2  | 111.7  |
| Regulation/Standard                                            | 277.6 | 566.7 | 821.4  |
| Agricultural                                                   | 109.3 | 313.6 | 583.4  |
| Nonagricultural                                                | 73.6  | 435.9 | 878.4  |

Each level of government differed in the type of tool it was most likely to use—both for rulemaking and implementing interventions. Acquisition rulemaking and implementation were conducted by all levels of government. Direct management occurred at the municipal and county levels. These activities sometimes respond to higher-level policies; for example, street sweeping and stormwater basin installations by counties and municipalities are carried out to comply with state-level Wisconsin Pollution Discharge Elimination System (WPDES) Municipal Permits. Incentives were written primarily by state and federal governments and implemented by the three lower levels of government. The county primarily implements federal programs such as NRCS's Environmental Quality Incentives Program (EQIP) (enabled by the Farm Bill); state programs such as the DNR Lake Classification Grants are granted by the state and carried out at the county and municipal level. Regulations and standards were also mostly written at higher levels and carried out at lower levels of government. We found six interventions directly promulgated by the federal CWA and administered by the State of Wisconsin; these policies were carried out by local governments through the WPDES permitting process and the CWA Section 303(d) impaired water body listing process. Dane County also has its own regulations for water quality, most concerning agricultural nutrient management and construction runoff.

#### 4.2. Targeting areas of concern for water quality

Analysis revealed a negative correlation between intervention coverage and subwatershed phosphorus yield for the combined interventions map ( $p < 0.001$ ) (Fig. 3). We also found significant negative correlations at all levels of government for both rulemaking and implementing levels with the exception of municipal rules (Table 3). Direct management, incentives, and regulations



**Fig. 3.** Intervention area on left (cumulative percent area covered by 35 possible interventions). Total phosphorus yield (kilograms lost per hectare per year) for 200 subwatersheds, modeled by [Montgomery Associates \(2011\)](#) on right. White indicates no data available.

were negatively correlated with high-phosphorus subwatersheds ( $p < 0.01$ ). The acquisition correlation with phosphorus hotspots was positive, but was not statistically significant ( $p = 0.131$ ).

We further divided the type of interventions by those explicitly targeting agricultural activities and those targeting non-agricultural land uses (those interventions targeting both were counted twice). Both types of interventions were negatively correlated with phosphorus yielding subwatersheds ( $p < 0.001$ ).

Cumulative percent area of interventions differed in urban and rural subwatersheds. We found that urban subwatersheds have a mean of 267 cumulative percent area coverage, compared to a mean of 213 in rural subwatersheds. Application of interventions was significantly higher in urban compared to rural subwatersheds ( $t$ -test,  $t = 6.490$ ,  $p < 0.0001$ ), indicating that urban subwatersheds receive more policy attention in the Yahara Watershed.

**Table 3**

Correlations between intervention coverage and phosphorus yield, by policy level and type ( $n = 200$  subwatersheds).

| Intervention category    | Pearson correlation coefficient | $p$ -value |
|--------------------------|---------------------------------|------------|
| All interventions        | −0.26                           | 0.000 ***  |
| Federal rule             | −0.26                           | 0.000 ***  |
| State rule               | −0.13                           | 0.065 *    |
| County rule              | −0.20                           | 0.004 ***  |
| Municipal rule           | 0.12                            | 0.097 *    |
| Federal implementation   | −0.30                           | 0.000 ***  |
| State implementation     | −0.22                           | 0.002 ***  |
| County implementation    | −0.33                           | 0.000 ***  |
| Municipal implementation | −0.17                           | 0.015 **   |
| Acquisition              | 0.13                            | 0.064 *    |
| Direct management        | −0.25                           | 0.000 ***  |
| Incentive                | −0.32                           | 0.000 ***  |
| Regulation/Standard      | −0.21                           | 0.003 ***  |
| Agricultural             | −0.30                           | 0.000 ***  |
| Nonagricultural          | −0.36                           | 0.000 ***  |

\* <0.10.

\*\* <0.05.

\*\*\* <0.01.

#### 4.3. Barriers to spatial targeting for water quality protection

Interviews and document analysis made clear that policy-makers have been engaged in long-term efforts to target policies to reduce nutrient and sediment runoff. For instance, the DNR's Priority Watershed Program targeted conservation funds to a high phosphorus-yielding northern Yahara subwatershed from 2001 to 2009, resulting in increased adoption of BMPs for barnyard waste management and cover cropping ([Betz & Genskow, 2012](#)). Yet our GIS analysis found overall negative correlations between areas of intervention and sources of phosphorus yield by subwatershed in the Yahara Watershed. Drawing on interviews with staff at the Dane County Conservation Division, Lakes and Watersheds Division, and County Executive's Office, we identified three overarching constraints on optimal targeting of agricultural conservation cost-share funds in the Yahara Watershed: (1) reliance on voluntary participation, (2) programmatic and funding constraints, and (3) imperfect knowledge of soil composition and land use practices. We focus on the management of nutrient runoff from agricultural lands because these lands contribute the majority of nutrients entering the Yahara lakes.

First, nonpoint source pollution programs are primarily voluntary. Cost-share funding from the US Farm Bill, Wisconsin DATCP and county conservation programs will pay for up to 70% of a typical farmer's costs of implementing a practice that reduces nutrient runoff. These practices include planting a winter cover crop to reduce erosion, using conservation tillage to minimize soil surface disruption, or leasing a special instrument to inject manure underground and prevent runoff. There are few regulatory mechanisms to enforce conservation standards on farms. Even though state erosion control rule NR151 allows counties to enforce conservation standards (primarily in the form of fines to a noncompliant landowner), the county must provide 70% cost-share and the procedures to compel compliance were described as onerous. Dane County's approach to allocating money is largely based on voluntary participation by agricultural producers who approach the office directly or have a history of working with the office. Staff also use awareness raising strategies in an effort to alert producers in a particular watershed that they can benefit from enrollment in a

conservation program—though one interviewee said that in recent years, announcements of new funding do not significantly increase the numbers of people contacting the office. For instance, a 2013 press conference by the County Executive announcing agricultural cost-share funding only brought in two phone calls from interested farmers. Voluntary program targeting could be increased with a greater pool of applicants to choose from in an area of concern, but staff generally do not go door-to-door asking producers in a target area to sign up, due largely to the financially-limited number of staff in the office.

Second, staff highlighted programmatic and funding constraints to effectively target phosphorus contributors of greatest concern. In the Yahara Watershed, federal NRCS programs are the largest funders of agricultural conservation. While Dane County may be interested in targeting conservation efforts toward areas contributing the most sediment and nutrient runoff to local waterways, funding from NRCS programs requires that properties be ranked through a system that incorporates national and statewide resource goals in addition to local goals. Targeting funding to farms with high nutrient runoff is available through the CWA Section 319 and Wisconsin Targeted Resource Management grants (Wisconsin Department of Natural Resources, 2011), but there is often less funding available for the targeted programs. For example, the Dane County Land Conservation Division received \$55,000 in 2012 from the Targeted Resource Management fund, while it received over \$1.4 million in federal, state, and county cost-share funding.

Third, interviewees indicated that accurate targeting for nutrient reduction is constrained by incomplete data, particularly at the farm and field scales. Dane County has access to several sources of information about the areas contributing the most nutrient pollution including models of phosphorus by subwatershed and a transect survey of soil loss levels in the county. However, the County faces the constant difficulty of first accessing data on private property and then making those data useful but not identifiable. Field-specific soil phosphorus data are not available to the public – or to some government agencies – for farms receiving USDA funds for nutrient management. Some companies, nonprofit organizations, and farmer led initiatives are declining to share information on soil phosphorus and runoff management with the County. At the field scale, the Wisconsin Phosphorus Index indicates the risk of soil nutrient runoff from farm fields and is calculated using information from farm nutrient management plans. County staff do not rely heavily on P Index data to identify farms for targeted participation, however, due to concerns over inaccurate model inputs or assumptions, and how data are received. Overall, in the view of a staffperson at the County Executive's office, in the absence of a cohesive mechanism to track and measure the impacts of dispersed farm practices, numerous local and state government agencies “try to keep compensating for this... by adding more programs,” rather than taking a more targeted approach to watershed nutrient reduction.

## 5. Discussion

We found extensive policy creation and implementation to improve water quality by multiple government agencies deploying diverse policy tools. While the presence of many actors and policy tools in a geographic region working on the same environmental problem may provide significant funding sources and staff, our results suggest that the product of combined interventions for nutrient reduction in the Yahara Watershed is not targeted at nutrient hotspots. None of the intervention patterns of the four government levels in our study had a significant positive correlation with high-phosphorus yielding subwatersheds, nor did the total set of interventions. Planning processes target areas contributing the

most sediment and nutrients to local waterways, but many barriers face spatial targeting under existing policy tools.

Our approach to spatial policy analysis has several important limitations. It does not indicate a causal relationship between policy effectiveness and phosphorus yield. This study was a first step in mapping multiple types of government interventions that did not estimate the amount of nutrient reduction generated by each policy. Future research should incorporate metrics of individual policy intervention effectiveness. There is also a need to compare policy targeting in different social and biophysical contexts.

### 5.1. Spatial configuration of interventions

We found that the spatial extent and location of multilevel interventions differed by level of government and type of tool deployed. These results reflect common understandings of how national- and local-level policies are implemented across a landscape. Federal policies have the ability to impact a problem on a regional or statewide scale (Margerum & Born, 2000), while local governments have more fine-scale impact (Leach et al., 2002). This distinction is demonstrated visually through our heat maps: the federal-level heat maps show relatively even coverage of the watershed, while the lower-level interventions show a much more local variation.

Our analysis emphasizes the critical role of local implementation. County government implements most of the water quality interventions in the watershed, and its position as an entity that receives funding and mandates from higher levels of government to distribute on the ground makes it critical in the multilevel context. Municipal governments are also important in that, unlike higher government levels, they directly implement management practices such as installing stormwater basins and removing leaves from streets. Policy and planning literature has long recognized the role of local and regional agencies in promulgating and carrying out land use policies (Bosselman & Callies, 1971), but their roles in receiving and distributing funds in the local context require increased recognition.

Choice of policy tool impacts the spatial extent and effectiveness of the policy for addressing an environmental problem. Regulatory restrictions may be applied to a large area for lower cost than incentives (Bengston et al., 2004), and certain rules do apply to large areas of the Yahara Watershed. The concentration of publicly-owned land in urban areas, and potentially greater acceptance of regulatory policies in urban areas (Warren, Ryan, Lerman, & Tooke, 2011) may explain the high intervention application in the Yahara Watershed's developed areas. But conservation regulations have been shown to have mixed ecological results when applied to a heterogeneous landscape (Butsic, Lewis, & Radloff, 2010). Incentives for environmental best management practices have been shown to encourage program participation to a greater degree than regulation in agricultural and natural area settings (Langpap, 2006; Lubell, 2004). Others suggest that regulation and incentives can be used together for greater leverage (Gerber & Rissman, 2012; Nie, 2008). Direct management of ecosystems, for instance the installation of stormwater basins, is spatially targeted, but typically has only short-term dedicated funding (Feitelson, 1992).

Choosing the policy tool to address a public problem is a political and a financial issue (Salamon & Elliot, 2002). One problem with many agencies implementing many different practices is that they may each use the tool that best fits their agency funding and mission, rather than the local context. Some scholars suggest that policy tool choice should be participatory and cognizant of long-term implementing relationships (Reed, 2008).

### 5.2. Targeting areas of concern for water quality

Our Yahara Watershed analysis reveals more intervention concentration in urban areas, and a negative correlation between

intervention coverage and phosphorus yield. This disconnect can be explained by several factors. Despite significant investment in agricultural areas, the CWA regulates point sources of water pollution – such as urban wastewater treatment plants – but not nonpoint sources, to which rural sources contribute disproportionately. Urban areas also have a bigger tax base and tend to have greater political clout to garner public attention to treasured natural places (Ferreyra, de Loe, & Kreutzweiser, 2008). This suggests the need to continue focusing effort on reducing nonpoint source pollution from agricultural lands.

Many efforts are designed to improve water quality targeting in agricultural and urban areas. Targeting for agricultural nutrient reduction is a focus of prominent initiatives, such as the NRCS Mississippi River Basin Initiative (Perez & Walker, 2014) and Wisconsin's Buffer Initiative (Diebel, Maxted, Nowak, & Vander Zanden, 2008). Other efforts focus on decision support systems for urban water managers targeting stormwater (Wong, Fletcher, Duncan, Coleman, & Jenkins, 2002). Yet most spatial targeting analyses optimize the allocation of individual policies. An integrated approach to watershed planning across the urban–rural gradient can help foster more targeted planning.

### 5.3. Barriers to spatial targeting for water quality protection

The gap between optimal planning and implementation is well recognized internationally (Knight et al., 2008). Decision support systems help plan where to target effort, but they do not address the challenges to conservation practice implementation. Four major barriers to targeting for agricultural nutrient management include nonparticipation, programmatic requirements, incomplete data, and the equity–efficiency tradeoff.

First, voluntary programs always have a challenge of nonparticipation, and it is difficult to specifically involve those whose lands disproportionately contribute to environmental problems (Genskow, 2012). A well-established line of inquiry has revealed the characteristics of farmers who are less likely to participate in conservation programs: generally, farmers who are older and less educated (Isik & Yang, 2004; Kraft, Lant, & Gillman, 1996), are lessees rather than owners, and have smaller farms (Kraft et al., 1996; Lambert, Sullivan, Claassen, & Foreman, 2007). Strategies to increase participation among these groups would increase opportunities for targeting.

Second, programmatic structure and requirements can constrain targeting and participation. In the Yahara Watershed, funding and programmatic constraints affected opportunities for spatial targeting. Reimer and Prokopy (2014) found that the complexity of the USDA incentives system may be a barrier that prevents participation by farmers with scarce time or resources. They suggested outreach efforts to increase awareness of program options, and future policy that balances program flexibility with complexity. Given the important role of local government in policy implementation, one would expect a degree of autonomy for local agencies to tailor policies to the local context. Yet there is often insufficient effort to engage either local government leaders or land managers. For instance, analysis of the NRCS Mississippi River Basin Initiative found that neither agricultural producers nor staff from other agencies working on the ground were significantly involved during this USDA program's design period (Perez & Walker, 2014).

Third, incomplete data constrains spatial targeting. Targeted conservation planning will inevitably miss some important regions due to data limitations (Carwardine, Klein, Wilson, Pressey, & Possingham, 2009). In the Yahara Watershed, lack of access to data about farm conditions has led to uncertainty in field-level targeting. Jackson-Smith, Halling, de la Hoz, McEvoy, and Horsburgh (2010) found that agency records of agricultural cost-share practices did not accurately represent their implementation. This issue

can create spatial biases in regional nutrient runoff modeling (Diebel et al., 2008). Furthermore, insufficient monitoring after implementation of conservation practices fails to provide evidence of program outcomes in many cases (Diebel et al., 2008).

Finally, the tension between equity and efficiency is an important consideration in conservation targeting. At the national level, equity of funding among states is a contested issue (Claassen, Cattaneo, & Johansson, 2008) and non-resource goals may take precedence in state-by-state EQIP allocations (Gilbert, Qin, Liu, & Neal, 2013). Some have argued, as a matter of equity and incentivizing desired behavior, that “good actors” – producers who have reached a high level of environmental performance – should be eligible for conservation cost share payments, even if these payments do not produce additional environmental gain (Claassen et al., 2008). In some cases, emphasizing social equity may be a more important goal than targeting particular resources.

## 6. Conclusions and policy recommendations

This analysis demonstrates a spatial disconnect between policy application and sources of water quality impairment. Our study points to an important research area that deserves more attention: linking spatial targeting with complex and multilevel policy arenas. Public agencies working to address the sources of nutrient pollution in Wisconsin's Yahara Watershed suffer from lack of coordination across government levels and lack of targeting by each level individually. This case reinforces the importance of overcoming structural and data limitations to effective targeting of public effort and funds. We highlight recommendations for policy tool choice, program administration, data access, and coordination to foster a more comprehensive approach to nutrient reduction in multilevel policy arenas. The lessons drawn from this case are relevant in other contexts where multiple organizations must coordinate for targeted natural resource conservation.

### Policy tool choice

Agencies should consider spatial targeting implications when selecting a policy tool. While regulatory permitting and compliance-related grants may direct attention and funds at areas of concern, most incentive-based and acquisition programs are more opportunistic or intentionally disperse funds evenly across landscapes. Yet heterogeneous landscapes call for a varied approach to conservation. The portfolio available to regional managers may benefit not only from a mix of incentive, acquisition, and direct management tools, but also from more regulatory tools that can target nonparticipants with high nutrient yields.

### Program administration

We suggest that program rules enable and encourage targeting. Targeting occurs at national to local levels, thus rules should be explicit about the scale of targeting, and the potential impacts of decisions made at one level on larger and smaller-scale targeting efforts. This may require a diagnostic approach by geographic scale and region, which may include allowing changes in grantee or cost-share ranking systems to better reflect regionally defined areas of concern, and longer grant cycles that give staff time to build relationships with nonparticipants.

### Data access

Water quality policies would benefit from greater spatial data to support subwatershed and farm-scale targeting. Targeting requires access to data on cost and estimated reduction in nutrient

yield and sediment loss derived from current soil nutrient levels and land use. Training for staff should be provided to enhance data collection and use; and data sharing agreements that apply to sharing among agencies, as well as between landowners and agencies, could improve coordination.

### Coordination

Multilevel governance with complex arrangements among agencies and partners complicates spatial targeting. This analysis illustrates the diversity of organizations working to improve water quality with multiple policy tools. Each level of government faces powerful limitations on optimal targeting including procedural constraints, difficulties in strategically attracting participants, addressing equity concerns, and collecting sufficient data for targeting and evaluation. In some cases, governments constrain each other's ability to target, such as federal and state programmatic restrictions on county decisions, and town and county government desires for equitable distribution of state funding. Planning for spatial targeting should acknowledge that government level creates variation in spatial concentrations of interventions. Collaborative approaches that include the experience of county governments

and districts are essential in the multilevel context. A comprehensive policy-in-action framework that includes spatial analysis would help governments improve targeting and coordination at the landscape-level.

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### Appendix A. List of mapped interventions with brief descriptions.

| #  | Intervention Name                                                                                                     | Rulemaking Agency Level  | Implementing Agency Level | Policy Tool Category (& subcategory)     | Short Intervention Description                                                                                                                               | Area (ha) |
|----|-----------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 1  | Federal Conservation Acquisitions                                                                                     | Federal                  | Federal                   | Acquisition (land conservation)          | US FWS* Leopold Wetland Management District                                                                                                                  | 952       |
| 2  | State Conservation Acquisitions                                                                                       | State                    | State                     | Acquisition (land conservation)          | WI DNR Stewardship Grant Acquisitions                                                                                                                        | 4,643     |
| 3  | County Conservation Acquisitions                                                                                      | County                   | County                    | Acquisition (land conservation)          | Dane Co. parkland and conservancy land; easements, including streambank                                                                                      | 1,941     |
| 4  | Municipal Conservation Acquisitions                                                                                   | Municipal                | Municipal                 | Acquisition (land conservation)          | Municipal parks and conservation lands                                                                                                                       | 2,926     |
| 5  | Municipal Street Sweeping                                                                                             | State, Municipal         | Municipal                 | Direct Management (urban stormwater)     | Collection of debris from municipal streets, spring through fall                                                                                             | 4,734     |
| 6  | Dane County Manure Digester and associated farms                                                                      | Federal, State, County   | County                    | Direct Management (agricultural erosion) | Phosphorus-removing manure digester, opened March 2011. Services 3 dairy farms.                                                                              | 293       |
| 7  | County and Municipal Stormwater Basins                                                                                | State, County, Municipal | County, Municipal         | Direct Management (urban stormwater)     | County and municipal public and private stormwater retention and detention basins, in compliance with stormwater discharge permits.                          | 2,384     |
| 8  | NRCS Conservation Stewardship Program (CSP)                                                                           | Federal                  | Federal, County           | Incentive (agricultural cost-share)      | Voluntary cost-share program (USDA-NRCS) for agricultural producers to address resource concerns by managing and adding to existing conservation activities. | 311       |
| 9  | NRCS Environmental Quality Incentives Program (EQIP), with additional cost-share funds from state and county programs | Federal, State, County   | Federal, County           | Incentive (agricultural cost-share)      | Voluntary cost-share program (USDA-NRCS) for agricultural producers to implement conservation practices that address natural resource concerns.              | 1,587     |
| 10 | NRCS Conservation Reserve Program (CRP)                                                                               | Federal                  | Federal, County           | Incentive (agricultural cost-share)      | Voluntary program (USDA-NRCS) provides annual rental payments and cost-share for long-term agricultural land retirement.                                     | 1,557     |
| 11 | DNR Targeted Runoff Management Grant Program Recipients                                                               | State                    | State, County, Municipal  | Incentive (government project support)   | Grant for local governments to reimburse costs for NPS control in critical geographic areas with water quality concerns.                                     | 416       |
| 12 | DNR Urban Nonpoint Source & Storm Water Management Grant Program Recipients                                           | State                    | State, County, Municipal  | Incentive (government project support)   | Grants to local governments to reimburse costs of projects controlling urban and storm water runoff pollution.                                               | 1,205     |
| 13 | DNR Lake Classification Grant Program Recipients                                                                      | State                    | State, County, Municipal  | Incentive (government project support)   | Grants to develop and implement land and water management programs targeted to specific lakes.                                                               | 1,205     |
| 14 | DNR Lake Management Planning Grant Program - Large and Small Scale Lakes Recipients                                   | State                    | State, County, Municipal  | Incentive (government project support)   | Funding for local governments and tribes to collect and analyze information needed to protect and restore lakes and watersheds.                              | 1,205     |

| #  | Intervention Name                                                                    | Rulemaking Agency Level           | Implementing Agency Level         | Policy Tool Category (& subcategory)                        | Short Intervention Description                                                                                                                                                                                                                | Area (ha) |
|----|--------------------------------------------------------------------------------------|-----------------------------------|-----------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 15 | DNR River Protection Planning & River Protection Management Grant Program Recipients | State                             | State, County, Municipal          | Incentive (government and non-governmental project support) | Grants for a river management organization; protection of rivers; river education projects; and plan development.                                                                                                                             | 1,205     |
| 16 | Dane County Environmental Council Grants Recipients                                  | County                            | County, Municipal                 | Incentive (government and non-governmental project support) | Grants to nonprofit community organizations, school districts, and municipalities for environmental initiatives.                                                                                                                              | 2,728     |
| 17 | 303(d) Listed Rivers for P, N or TSS                                                 | Federal, State                    | Federal, State                    | Regulation/Standard (general land use)                      | The WI DNR maintains a list of water bodies that do not meet the State's water quality standards, in compliance with the CWA.                                                                                                                 | 73,946    |
| 18 | Dane County Nutrient Application Restriction Areas (>9% Slope)                       | State, County                     | County                            | Regulation/Standard (agricultural)                          | Dane County Ch. 14 regulates the amount of liquid manure that may be spread on land. Amount of manure allowed is determined in part by slope of spreading area.                                                                               | 26,171    |
| 19 | Dane County Winter Spreading Permits                                                 | Federal, State, County            | County                            | Regulation/Standard (agricultural)                          | Dane County Ch. 14 permits to agricultural producers for winter spreading of manure on fields.                                                                                                                                                | 10,334    |
| 20 | Municipal Livestock Siting Rule                                                      | State, Municipal                  | Municipal                         | Regulation/Standard (agricultural)                          | Municipalities may require conditional use or other permits for siting new and expanded livestock operations.                                                                                                                                 | 12,597    |
| 21 | Shoreland District (1000ft from HWM of lake, pond, or flowage)                       | State, County                     | County, Municipal                 | Regulation/Standard (general land use)                      | Wisconsin Ch. NR 115 regulates land disturbing activities within 1000ft of high water mark of lake, pond, or flowage. SWQMA Permit required.                                                                                                  | 16,905    |
| 22 | Shoreland District (300ft from HWM of navigable river or stream)                     | State, County                     | County, Municipal                 | Regulation/Standard (general land use)                      | Wisconsin Ch. NR 115 regulates land disturbing activities within 300ft of high water mark of navigable river or stream. SWQMA Permit required.                                                                                                | 7,057     |
| 23 | Regulated Wetland Disturbance                                                        | Federal, State, County, Municipal | Federal, State, County, Municipal | Regulation/Standard (general land use)                      | Filling/degradation of wetlands prevented through the CWA, State wetland regulations, and wetland zoning.                                                                                                                                     | 10,361    |
| 24 | WPDES - CAFO Permits                                                                 | Federal, State                    | State, County                     | Regulation/Standard (agricultural)                          | CWA and Wisconsin Ch. NR 243 regulate manure management on CAFOs.                                                                                                                                                                             | 660       |
| 25 | WPDES - Industrial Wastewater Permits                                                | Federal, State                    | State                             | Regulation/Standard (wastewater)                            | CWA and Wisconsin Ch. NR 216 regulate point source discharges of pollutants to waters of the state through WPDES permits. Here, industrial permittees.                                                                                        | 565       |
| 26 | WPDES - Municipal Wastewater Treatment Facilities (WWTF) Permits                     | Federal, State                    | State                             | Regulation/Standard (wastewater)                            | CWA and Wisconsin Ch. NR 110 regulate point source discharges of pollutants to waters of the state through WPDES permits. Here, municipal wastewater treatment facility permittees.                                                           | 24,566    |
| 27 | WPDES - Municipal (MS4) Wastewater Permits                                           | Federal, State                    | State                             | Regulation/Standard (wastewater)                            | CWA and Wisconsin Ch. NR 216 regulate point source discharges of pollutants to waters of the state through WPDES permits. Here, municipal permittees.                                                                                         | 24,406    |
| 28 | Rock River TMDL                                                                      | Federal, State                    | Federal, State, County, Municipal | Regulation/Standard (general land use)                      | The WI DNR develops a TMDL for watersheds surrounding a 303(d) listed water body.                                                                                                                                                             | 134,573   |
| 29 | Agricultural Nonpoint Performance Standards and Runoff Management (NR 151)           | State                             | State, County                     | Regulation/Standard (agricultural)                          | Wisconsin Ch. NR 151 regulates farms, which must: Meet soil loss requirements; Annually develop and follow a Nutrient Management Plan (NMP); ensure that their NMP adequately controls runoff; avoid tilling within 5 feet of surface waters. | 63,719    |
| 30 | Non-Agricultural Performance Standards and Runoff Management - Construction (NR 151) | State                             | State, County, Municipal          | Regulation/Standard (general land use)                      | Wisconsin Code Ch. NR 151 sets statewide performance standards and prohibitions for Wisconsin non-agricultural land uses including construction and transportation facilities.                                                                | 60,142    |
| 31 | County/Municipal Erosion Control Permitting Program                                  | County                            | County                            | Regulation/Standard (general land use)                      | Dane County Chs. 11 and 14 require an Erosion Control Permit for significant land disturbing activities, including on a slope of greater than 12 percent and in shoreland districts.                                                          | 27,592    |
| 32 | Phosphorus Lawn Fertilizer Restrictions - Dane County                                | County                            | County                            | Regulation/Standard (residential)                           | Dane County Ch. 80 prohibits use of phosphorus-containing lawn fertilizers.                                                                                                                                                                   | 58,043    |
| 33 | Phosphorus Lawn Fertilizer Restrictions - Wisconsin                                  | State                             | State, County                     | Regulation/Standard (residential)                           | Wisconsin Ch. 94 restricts use of phosphorus-containing lawn fertilizers.                                                                                                                                                                     | 60,484    |
| 34 | Dane County Environmental Corridors                                                  | State, County                     | County                            | Regulation/Standard (municipal land use)                    | Environmental corridors are continuous open space requiring protection from development.                                                                                                                                                      | 7,784     |
| 35 | Municipal Stormwater Ordinances - 100 year storm peak runoff design standard         | County, Municipal                 | Municipal                         | Regulation/Standard (municipal land use)                    | Municipalities that have adopted more stringent design standards for construction runoff.                                                                                                                                                     | 33,263    |

## Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.landurbplan.2014.12.011>.

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