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Catalyzing Change: Social Science for Water Resources Management

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Managing water resources is becoming increasingly difficult as demographic, economic, institutional, technological, and climate changes manifest across the U.S. and around the world (Cosgrove and Louchs 2015). These extraordinarily complex water quality and quantity challenges facing water resource management are "wicked problems" (Gold et al. 2013). Wicked problems - those that are difficult to resolve because of complexity, uncertainty, and divergence and fragmentation in viewpoints, values, and intentions (Rittel and Webber 1973; Head 2008) - arise in numerous resource management contexts. The act of simply trying to define the problem illustrates the level of difficulty associated with resolution. For example, multiple perspectives on an issue, the level to which numerous social and natural systems are connected, and the overwhelming number of potential fixes that need to be understood to clearly define the issue make water management a wicked problem.

Historically, water problems have been regarded as requiring engineering or technological fixes. However, because most water problems are largely the result of human activity (Schultz 2011; Rockström et al. 2014), it is the social - not technical - complexity of these problems that overwhelms water management. Social factors (e.g., equity, water rights, norms, attitudes, values, beliefs, etc.) are often the primary determinants of management success or failure (Mascia et al. 2003; Floress et al. 2015). Thus, the resolution or mitigation of wicked water problems requires interdisciplinary collaboration, particularly from the social sciences, to foster new thinking, behavior, and innovative ideas for management of water resources under conditions of rapid change and uncertainty (Jury and Vaux 2005).

> *One of the anomalies of modern ecology is that it is the creation of two groups each of which seems barely aware of the existence of the other. The one studies the human community almost as if it were a separate entity, and calls its findings sociology, economics, and history. The other studies the plant and animal community, [and] comfortably relegates the hodge-podge of politics to "the liberal arts." The inevitable fusion of these two lines of thought will, perhaps, constitute the outstanding advance of the present century.* — Aldo Leopold

Despite the social complexity of water challenges, most people working in water resource management are trained in the bio-physical sciences, in turn limiting access to knowledge that could be gained from social sciences (Floress et al. 2015). Water resource professionals and the staffs of myriad water-related agencies tend to have backgrounds in engineering, hydrology, ecology, aquatic sciences, and so on. Thus, agencies and organizations may not have the necessary skills to effectively address the human dimensions of water resource management (Sexton et al. 2013). Many lack the capacity to deal with the social complexity and interdependencies of current water

resource management. "The management of water resources is currently undergoing a paradigm shift toward a more integrated and participatory management style" (Pahl-Wostl et al. 2007, p. 1) in order to address "complex interdependencies, human behavior and social institutions" (Pahl-Wostl et al. 2012, p. 25). Future water management will require new and continuous learning, new patterns of behavior, and innovative thinking (Uhl-Bien et al. 2007; Berry 2017). This requires that water resource managers develop the capacity to catalyze change and advance innovative solutions within integrated and participatory management approaches.

Since most wicked water resource problems are caused by or concern human behavior, leaders in water resource management must understand and be capable of changing behavior to solve them (Schultz 2011; Faruqi 2012). Development of essential skills to catalyze change or respond to external catalysts (e.g. Prokopy et al. 2014) is paramount. Catalyzing change begins with new knowledge and readiness to change. The ability to create and transfer new knowledge is a foundational skill to effect change in others, communities, or policy (Schultz 2002; Kaiser and Fuhrer 2003).

> *Human behavior flows from three main sources: desire, emotion, and knowledge* — Plato

However, those involved in water resource management must also be able to motivate change in others, develop the ability to assist others in sustaining the behavior change, and recognize and support the practice of the behavior change (Beer et al. 2016). They must facilitate others engagement with new concepts in the context of their own lives, critical reflection, and reinforcement for the new behavior to become enduring (Bandura 1977; Argyris and Schon 1978; Mezirow 1997).

> *For the environment after all is where we all meet; where we have a mutual interest; it is one thing that all of us share. It is not only a mirror of ourselves, but a focusing lens on what we can become* — Lady Bird Johnson

To change behaviors, we have to understand how to train leaders in social science skills and evaluating success. This special issue uses case studies to demonstrate how social science concepts, theories, and methods are used to catalyze change across a range of water resource management issues and geographic scales. Supporting water management programs with information from the social sciences provides a framework for program design, implementation, and evaluation necessary for resolving wicked problems.

Through a series of case studies predominantly from the Midwestern United States, this issue provides those involved with water management - or students learning about it - a resource useful for understanding how social science research can help them achieve desired outcomes more effectively. The case studies range from using applied gaming to expand knowledge of water issues to evaluating statewide water leadership programs, and each includes practical applications and impacts related to using specific social science approaches (Table 1). Together, the cases accentuate the need for partnerships between social scientists and practitioners.

Burbach and Reimers-Hild use leadership theory to develop catalysts of change in a comprehensive water leadership academy in Nebraska. They describe how future water leadership programs must evolve to meet the increasing challenges facing water management. They use pre- and post-program skills assessment and other program evaluation methods to demonstrate how a process-based curriculum with developmental experiences can affect behavior change in participants. This article demonstrates how the social sciences can guide the construction, conduct, and assessment of a water leaders development program.

In the following article, Bonnell et al. used interviews with watershed professionals to develop a framework of effective watershed leadership that has three categories of skills: technical, administrative, and social. The results from these interviews inform understanding of collaborative watershed management in general. More specifically these results are used to improve programming in the Ohio Watershed Leadership Academy.

Kaufman et al. demonstrate how they used a mixed methods research approach to explore and explain eco-leadership in the context of community organizations that have the potential to engage in community watershed protection efforts. They

demonstrate the value of both quantitative and qualitative strands to enrich our understanding of eco-leadership.

Moving away from leadership-related research, Bathke et al. describe the utility of applied games for public participation and expanding systems thinking regarding resource management issues. Within the context of an agricultural watershed, the authors develop, implement, and evaluate a Multi-Hazard Tournament requiring participants to collaboratively adapt to flooding, droughts, and water quality changes that stem from climate extremes. They show how the game improved participants' knowledge of issues and potential actions; knowledge of and opportunities for collaboration with other participants; and feelings of empowerment to put their new knowledge and skills to work when making decisions.

Table 1. Overview of Articles in Special Issue.

Article Authors	State	Stakeholders, program, or process studied	Theoretical or Conceptual Framework	Data Collection Methods	Data Analysis Methods
Burbach & Reimers-Hild	Nebraska	Formal water leadership program	McCauley et al. (2010) model of leadership development	Pre-/post- skills assessments; program evaluation	Statistical analysis; difference in means
Bonnell et al.	Ohio	Watershed professionals	Collaborative watershed management	Interviews	Coding, categorizing, and theme searching of interview transcripts
Kaufman et al.	Virginia	Community organizations	Eco-leadership	Surveys and focus groups	Descriptive and correlational statistics; coding of qualitative data; crossover tracks analysis
Bathke et al.	Minnesota/ Iowa	Diverse participants in serious game	Applied gaming	Pre-surveys, surveys immediately after event; surveys 3 months after event	Primarily qualitative assessment of change
Bentlage et al.	Indiana	Riparian landowners; river recreationists	Community based social marketing	Pre-/post- surveys (in-person and mail); stakeholder input session	Statistical analysis; difference in means
Church et al.	Indiana	Collaborative watershed management project	Formative, process and summative evaluation	Pre-/post- surveys; interviews; participant observation	Statistical analysis: difference in means; qualitative coding
Floress et al.	Wisconsin	Lake and water management policies; policy networks	Community capacity; good governance	Semi-structured interviews; policy documents; web survey	Policy content analysis; thematic interview coding

Bentlage et al. describe how they developed a community-based social marketing campaign to influence the awareness, attitudes, and behaviors of riparian landowners and recreational users of a river in northwestern Indiana. Focusing on the role of freshwater mussels and their dependence on clean water, this social marketing campaign was informed by in-person and mail baseline surveys and a stakeholder input session. At the completion of the campaign, surveys were again used to evaluate overall success. This article illustrates how social science data can be used both before and after an outreach campaign.

A comprehensive evaluation of a collaborative watershed management process in North Central Indiana is presented by Church et al. Ongoing efforts to encourage farmers to adopt conservation practices in the predominantly agricultural Beargrass Watershed were enhanced in 2014 with an infusion of monetary and technical support to the local Soil and Water Conservation District. They discuss how surveys and interviews conducted at the beginning of this process helped to inform the subsequent messaging of practices to farmers and how participant observation during the outreach stage of the project was used to continue to refine messaging. Finally, they discuss how end-of-project surveys and interviews were used to evaluate the effectiveness of the watershed process.

Floress et al. describe an investigation of good water governance principles to support managing Lake Wausau, an impounded lake on the Wisconsin River. Intended to support the work of local leaders and resource management professionals, they used policy content analysis, semi-structured interviews, and a web-based survey to assess the extent to which the system of governance was transparent, effective, equitable, accountable, and appropriately scaled. They discuss barriers to and opportunities for a more effective system of governance, along with suggestions for projects considering similar endeavors.

Complex water resource management requires interdisciplinary collaboration. Those involved in water resource management are increasingly called upon to incorporate social science theories, concepts, and methods into their practice to solve wicked water problems involving human behaviors and institutions. It is our hope that the cases in this special issue highlight some of the ways in which social science has contributed to more effective water programs.

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