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Robert S. Stelzer
Department of Biology and Microbiology, University of Wisconsin Oshkosh, Oshkosh, WI

Donna R. Kashian
Department of Biological Sciences, Wayne State University, Detroit, MI, dkashian@wayne.edu

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The role of conservation partnerships between scientists and nonprofit agencies in freshwater science and management

Robert S. Stelzer[1,3] **and Donna R. Kashian**[2,4]

[1]Department of Biology and Microbiology, University of Wisconsin Oshkosh, 800 Algoma Boulevard, Oshkosh, Wisconsin 54901 USA
[2]Department of Biological Sciences, Wayne State University, Detroit, Michigan 48202 USA

Scientists and policy makers have identified several problems affecting freshwater ecosystems and water resources, including: eutrophication (Smith et al. 1999, Bianchi et al. 2010), loss of biodiversity (Dudgeon et al. 2006), water scarcity (Postel 2000, Foster and Chilton 2003), and degraded water quality (Lapworth et al. 2012). Responses to these and other problems have led to advances in technology, policy, and management, such as improvements in pollution control measures (Dolan 1993) and fisheries regulations (Bruch 1999), that have benefited freshwater ecosystems. Many of these advances originated from research by professional scientists that led directly to management or policy action. For example, insights into natural flow regimes of rivers and how altered flow regimes can affect river ecosystems (Poff and Ward 1990, Naiman et al. 1995, Poff et al. 1997) led to improvements in environmental flow assessments (Tharme 2003, Poff et al. 2009) and have informed river restoration projects (Arthington et al. 2010, King et al. 2010). In this traditional model, research-based knowledge trickles down or is transferred to and translated by policy makers and natural resource managers (van Kerkhoff and Lebel 2006). The traditional model has undoubtedly been successful, in at least some cases, in addressing environmental problems.

van Kerkhoff and Lebel (2006) critiqued the traditional model of research-based knowledge transfer and presented alternative models that may be more successful for progress in sustainable development. Their critique centered on limitations on successful transfer of information to policy makers and natural-resource managers via the traditional model because of the social context within which science is done and because of barriers to implementation of the recommendations that emerge from scientific studies. van Kerkhoff and Lebel (2006) proposed 4 alternative models of knowledge transfer: 1) participation, 2) integration, 3) learning, and 4) negotiation. In the participation model, individuals or small groups of nonscientists participate in data collection to address an environmental question or issue. The issue addressed and the type of data collected are determined by researchers or policy-makers (van Kerkhoff and Lebel 2006). The integration model involves interaction and cooperation among scientists, policy makers, managers, and other users of research results. For example, an integrated approach to water management in a watershed might include shared decision-making by specialists from different disciplines and stakeholders in the watershed (van Kerkhoff and Lebel 2006). The learning model involves sharing of knowledge between researchers and nonscientists as an ongoing process and includes adaptive-management approaches. In the negotiation model, active engagement exists among researchers, policy makers, and other stakeholders. Researchers may serve as important advocates for science on particular political issues. All of these alternative models recognize and embrace the social context of science. Most environmental issues, such as global climate change and perturbations of water quantity and quality, have scientific and social dimensions (Folke et al. 2002, Richter et al. 2006, Poff et al. 2009), so the alternative models may be more adept than the traditional model alone at addressing environmental problems.

E-mail addresses: [3]stelzer@uwosh.edu; [4]dkashian@wayne.edu

**BRIDGES is a recurring feature of FWS intended to provide a forum for the interchange of ideas and information relevant to FWS readers, but beyond the usual scope of a scientific paper. Articles in this series will bridge from aquatic ecology to other disciplines, e.g., political science, economics, education, chemistry, or other biological sciences. Papers may be complementary or take alternative viewpoints. Authors with ideas for topics should contact BRIDGES Co-Editors, Ashley Moerke* (amoerke@lssu.edu) *and Allison Roy* (aroy@eco.umass.edu).

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Realization is growing that solutions to ongoing and emerging threats to freshwater ecosystems and water resources require collaborative approaches that engage scientists, policy makers, the private sector, and other stakeholders. The history of collaboration between scientists and citizen volunteers in the environmental sciences is rich (Dickinson et al. 2012, Miller-Rushing et al. 2012). For example, the North American Breeding Bird Survey conducted by nonprofessional and professional ornithologists has helped document the population status of many bird species in the Western Hemisphere (Robbins et al. 1996). Partnerships have long existed among scientists, nonprofit organizations, and volunteers interested in freshwater ecosystems. For example, for several decades, fisheries biologists have partnered closely with anglers to gain information about the size, age, and location of harvested fishes through tag returns (Cardona-Pons et al. 2010, Meyer et al. 2012). These data are used by fisheries biologists for developing population estimates (Pine et al. 2003), validating ages (Bruch et al. 2009), and assessing fish movement patterns (Hilborn 1990). One criticism of volunteer monitoring programs is that the results do not necessarily inform decisions made by natural-resource managers or lead to policy change. Improving estimates of bird and fish population sizes, as described above, have clear implications for natural resource management. However, few investigators have attempted to quantify the management implications of collaborations between scientists and citizen volunteers. In one study, Danielson et al. (2005) showed that a biodiversity monitoring scheme in the Philippines by park rangers and community volunteers led to ~150 conservation management interventions and that the most participatory field-monitoring technique led to the largest number of interventions.

In the last 20 y, the number of partnerships among aquatic scientists, resource managers, and citizen volunteers that have centered on environmental monitoring of streams and lakes has increased. Aspects of aquatic ecosystems that have been monitored by participants in these partnerships include invertebrate communities (Nerbonne and Nelson 2004), microbial indicator species (Stepenuck et al. 2011), surface water hydrology (Turner and Richter 2011), and water clarity (Chipman et al. 2004). The quality of environmental data collected by volunteers has been evaluated several times (e.g., Fore et al. 2001, Nerbonne et al. 2008, Latimore and Steen 2014). In this *BRIDGES* cluster, we focus on conservation partnerships among professional scientists, nonprofit agencies, and unaffiliated citizens and describe how these partnerships can improve understanding and management of freshwater ecosystems and resources. We have placed these articles in the context of the alternative models linking knowledge and action proposed by van Kerkhoff and Lebel (2006).

Kashian et al. (2014) presented a case study that reflects the integration model. In this case, the funding source, Michigan Sea Grant, solicited project ideas from local agencies on relevant natural resource and environmental issues. The goal was to identify research projects that could provide high-priority deliverables to managers or stakeholders in need of this information. Michigan Sea Grant used these project ideas to solicit research proposals focused on promoting translational research that delivered useful outcomes and increased dialog and partnering among researchers, managers, and other interested stakeholders. Kashian et al. (2014) described the process by which they increased stakeholder capacity to address the issue of fish consumption advisories in the Detroit River by increasing engagement, coordination, and communication among stakeholders. These efforts led to identification of the top 5 concerns related to fish consumption advisories in the Detroit River. The stakeholders were able to address some of these issues by including an additional fish species in the advisory and by developing outreach materials.

Latimore and Steen (2014) provided an example of the benefits of the participation and learning models described by van Kerkhoff and Lebel (2006). Latimore and Steen (2014) showed how the Michigan Clean Water Corps (MiCorps) has expanded monitoring opportunities for citizen volunteers and has led to production of a reliable database on freshwater ecosystems. The data have been used by local lake and river associations to develop watershed management plans and by state natural resource agencies to meet their planning and reporting needs. The MiCorps database also has been used as part of a cooperative partnership between citizen scientists and researchers to identify linkages between zebra-mussel invasion status, total P, and concentrations of microcystin (a cyanobacterial toxin) and to fill gaps in these data for Michigan lakes.

In the final article in the cluster, Isley et al. (2014) described 2 collaborative projects in western Michigan that incorporated multiple aspects of the van Kerkhoff and Lebel (2006) framework. First, Isley et al. (2014) described a community-based integrated assessment of stormwater runoff and management in the watershed of a drowned river mouth lake. This assessment incorporated elements of the integration and participation models in the van Kerkhoff and Lebel (2006) framework. Second, Isley et al. (2014) described a project that used an ecosystem-services valuation model to inform conservation planning on a parcel of land that contains a variety of upland and wetland habitats near Lake Michigan. The project was carried out using elements of the negotiation model (van Kerkhoff and Lebel 2006). Isley et al. (2014) used these examples to highlight some of the benefits and potential roadblocks that can occur in partnerships between scientific researchers and stakeholders, and they emphasized the importance of sustaining relationships in these partnerships.

The various research projects described in this cluster are relatable, real-world examples of applications of the models in van Kerkhoff and Lebel's (2006) engagement framework. Funding agencies and scientific researchers are finding increasingly often that partnerships with nonprofit organizations and local communities are necessary to obtain sustainable outcomes (Pohjola and Tuomisto 2011). Scientists, nonprofit organizations, community members, and managers can extract ideas from these examples to guide development of successful new partnerships. Professional scientists and the community at large, including nonprofit organizations, benefit from increased engagement and power sharing.

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