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Using Socioenvironmental Report Cards as a Tool for Transdisciplinary Collaboration

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ABSTRACT

The process of developing a socioenvironmental report card through transdisciplinary collaboration can be used in any system and can provide the foundation for collaborative solutions for sustainable resource management by creating a holistic assessment that balances environmental, economic, and social concerns that incorporates multiple perspectives from multisectoral actors. We demonstrated this in the Mississippi River watershed, USA with the ultimate goal of promoting holistic management of the region's natural resources. But working at the scale of the Mississippi River watershed presents the challenge of working across geographical, organizational, and disciplinary boundaries. The development of a socioenvironmental report card served as the focus for efforts to foster a shared vision among diverse stakeholders in the watershed and to promote transdisciplinary collaboration. The process engaged more than 700 participants from environment, flood control, transportation, water supply, economy, and recreation sectors, from more than 400 organizations representing local, state, and federal government agencies, businesses and trade associations, and private, nonprofit, and academic institutions. This broad engagement in the selection of important themes, indicators, measures, and assessment methods as part of the cocreation of boundary objects aimed to foster social and mutual learning and to develop common understanding and shared visioning among stakeholders with differing perspectives. The process was facilitated by boundary-spanning organizations, creating an atmosphere of trust by utilizing "third places" for knowledge exchange and integration. This transdisciplinary process also led to collective action through collaboration and selection of restoration and management activities that could improve conditions for multiple sectors simultaneously and/or recognize potential tradeoffs for informed decision making. *Integr Environ Assess Manag* 2020;16:494–507. © 2020 The Authors. *Integrated Environmental Assessment and Management* published by Wiley Periodicals, Inc. on behalf of Society of Environmental Toxicology & Chemistry (SETAC)

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INTRODUCTION

Transdisciplinary collaboration in the context of integrated management (Allen et al. 2011) allows for multisectoral stakeholders to reconcile a diversity of perspectives and act together more effectively to pursue shared objectives (Putnam 1995), leading to collective action (Vanni 2014) and collective impact (Kania and Kramer 2011). Transdisciplinarity promotes social learning or mutual learning through the use of "third places" and the codevelopment of "boundary objects" (Jahn et al. 2012; Vilsmaier et al. 2015; Roux et al. 2017). Third places are learning spaces where diverse stakeholders meet and share experiences with an equal voice (Roux et al. 2017) allowing for knowledge exchange, integration, and production to occur. Examples of boundary objects include models, indicators, and maps that allow for different groups to share meaning and incorporate individual perspectives while still maintaining an identity that is recognized by all (Star and Griesemer 1989; Fox 2011; Jahn et al. 2012; Roux et al. 2017). Ideally, transdisciplinary processes are facilitated by boundary-spanning organizations that help increase the legitimacy of science by fostering trust and sustaining interaction and engagement among the participants

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(Scholz and Steiner 2015; van Kerkhoff and Pilbeam 2017; Bednarek et al. 2018).

The codevelopment of boundary objects is key in sustaining stakeholder engagement by enabling participants to develop a shared understanding, fostering trust in the collaboration process. Facilitating the creation of boundary objects can be daunting, however, requiring capacity in planning, facilitation, and communication. The objective of the present paper is to illustrate how a socioenvironmental report card is a boundary object that can serve as a platform for transdisciplinary collaboration and a catalyst for collective action. We illustrate the codevelopment process as a practical solution for achieving stakeholder engagement, providing opportunities for collective action in complex systems. We describe the process here as a guide for others, using the Mississippi River Watershed Report Card as a case study.

Report cards are assessment and communication products that compare a region's ecological, social, and economic status with predefined goals or objectives (Costanzo et al. 2017). They can synthesize large quantities of complex information into comprehensive letter-grade scores that can be easily communicated to decision makers and the public. Although the use of ecosystem health report cards has been increasing (Williams et al. 2009; Harwell et al. 2019), the Mississippi River Watershed Report Card was the first of its kind, not only in its geographical scope and the inclusion of both ecological indicators and socioeconomic indicators but also in the stakeholder engagement approach that was utilized. The codesign and coproduction process for the report card is unique and has allowed for the engagement of a diverse multisector group of stakeholders through multiple workshops that served as third places and the codevelopment of boundary objects such as conceptual diagrams and maps, newsletters, and the report card product itself. This process has since been applied in diverse locations and contexts worldwide, resulting to socioenvironmental report cards that were codesigned by stakeholders to reflect their values and interests.

The Mississippi River watershed is the third largest watershed in the world, covering more than 41% of the continental United States and including parts of 31 states and 2 Canadian provinces (MRCSC 1996). Many different users depend on the watershed, but this diversity of interests also leads to competition and conflict over the use of the river's natural resources. Increasingly, stakeholders throughout the watershed recognize the need to extend the scope of existing cooperation in the management of natural resources to incorporate a broader scope of interests and larger geographical scale (Meridian Institute 2010; Walsh and Mulcahy 2010). This, however, is challenging because in addition to the diversity of management objectives, constituencies, and decision makers, there are also significant geographic, environmental, economic, and social differences across the watershed (MRCSC 1996).

Some of the more active sectors engaged in management include conservation, navigation, industry, agriculture, water supply, recreation, flood control and risk reduction, and energy (coal and gas extraction and hydroelectric power generation). Protection, conservation, and restoration of water quality; wildlife habitat; water quantity and allocation; navigation infrastructure; flood control and risk reduction; and water treatment and supply are interconnected and have significant local and watershed-wide impacts (MRCSC 1996; Turner and Rabalais 2003; Camillo and Pearcy 2004; NRC 2008; White et al. 2014). Thus, many stakeholders have reported widespread challenges to their interests and an inability to address their issues and meet their objectives without developing broader coalitions and partnerships (Meridian Institute 2010; Walsh and Mulcahy 2010).

The challenge is to implement new management approaches for these sectors that recognizes their impacts on other sectors. For example, how can ecosystem health, water supply, hydropower, economic vitality, and recreational opportunities be maintained or improved while also preserving the navigation and flood risk reduction improvements created through the Mississippi River and Tributaries Project (MR&T) that is implemented by the US Army Corps of Engineers (USACE) (Camillo and Pearcy 2004; Camillo 2012). Traditional natural resource management approaches are bounded by human-made jurisdictional borders, whereas ecological processes operate across various spatial and temporal scales (Sayles and Baggio 2017). These differences often lead to ineffective natural resource management (Cumming et al. 2006; Folke et al. 2007).

One approach to addressing these types of multiscale and multisectoral issues, and the disconnect between management activities and societal outcomes, is through integrated management that is grounded on transdisciplinary collaboration such as watershed-based approaches (NRC 1999), integrated river basin management (Jaspers 2003), and integrated catchment management (Allen et al. 2011). In the Mississippi River watershed, this has been addressed to some extent at the basin level through the formation of basin compacts such as the Ohio River Valley Water Sanitation Commission, the Tennessee Valley Authority, the Mississippi River Commission, Missouri River Commission, and the Red River Compact. However, a watershed-wide integrated and holistic management effort has not been initiated for the whole Mississippi River watershed (Hooper 2012).

The process of developing a holistic socioenvironmental report card for the Mississippi River watershed fostered a shared vision among diverse stakeholders. This was achieved through transdisciplinary collaboration by 1) managing boundaries, 2) actively engaging diverse stakeholders, and 3) creating a shared understanding through the cocreation of boundary objects. The present paper is structured as follows: First, we discuss the events that led to the decision to use a report card as a tool to develop a shared, long-term vision for the Mississippi River watershed. Second, we evaluate the strategies that were used for developing the report card,

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which centered around 2 important transdisciplinary principles: stakeholder engagement and codevelopment of boundary objects. We then discuss the results achieved through the report card process in building social networks and as a rallying point for collective action and collective impact. Finally, we give our reflection on the report card process as a transdisciplinary collaboration, the lessons learned, and our recommendations.

TOWARD A SHARED VISION FOR THE MISSISSIPPI RIVER WATERSHED

The Mississippi River watershed includes the Mississippi River and major tributaries, including the Missouri, Ohio, Arkansas, and Red rivers (Figure 1). It has a rich history for multisectoral, transboundary management under the rubric of Integrated River Basin Management. However, these existing entities operate at the basin level and employ a mostly top–down management approach. In 2008, a National Research Council (NRC) report went so far as to call the Mississippi River an “orphan” because no agency, program, or entity oversees the entire river (NRC 2008). In 2009, a series of interviews with diverse geographic and sector stakeholders were completed to gather information about support for developing a long-term, intergenerational vision for the Mississippi River watershed (Meridian Institute 2010). A consistent result in the interviews was the need to develop a shared, holistic vision for the future of the Mississippi River watershed that integrated ecological, social, and economic concerns. The respondents wanted this vision to help create commonly accepted priorities for the watershed. This information helped shape the agenda for the 2010 America's Inner Coast Summit in St Louis, Missouri. At the conclusion of the summit, the participants asked The Nature Conservancy and the USACE to convene a steering committee of stakeholders to support developing a shared future vision and seeking solutions for meeting the multiple demands placed on the Mississippi River watershed system by integrating issues, partners, and ideas at the full watershed scale (Walsh and Mulcahy 2010). This became the America's Watershed Initiative (AWI) Steering Committee.

The Nature Conservancy, as a member of the steering committee, secured and allocated the funding needed to hire a director and begin the process to advance the AWI. The steering committee then organized a series of high-level stakeholder watershed summits to identify a tool to help define and shape a common long-term vision and to identify goals shared by stakeholders for the future of the watershed. Following these summits, a report card assessment was chosen as the best tool for establishing baseline conditions and developing the shared, long-term vision for the watershed, which would be based around 6 goals:

1) Maintain supply of abundant clean water
2) Provide reliable flood control and risk reduction
3) Support local, state, and national economies
4) Support and enhance healthy and productive ecosystems
5) Provide world-class recreation opportunities
6) Serve as the nation's most valuable river transportation corridor.

A seventh goal, national security, was initially selected but later dropped as impractical.

Figure 1. The Mississippi River watershed. The Mississippi River Watershed Report Card was built in 5 major basins, including the Upper Mississippi River, Lower Mississippi River, Missouri River, Arkansas and Red rivers, and Ohio River. Workshops and summits were conducted throughout the watershed to solicit feedback from experts from these regions.

The AWI Steering Committee partnered with Integration and Application Network, University of the Maryland Center for Environmental Science (IAN-UMCES) to help develop this report card. The IAN-UMCES has been instrumental in the development of ecosystem health report cards globally, most notably in the Chesapeake Bay (Williams et al. 2009), the largest estuary in the United States, and the Great Barrier Reef in Australia (State of Queensland 2011), among many others. The IAN-UMCES generally follows a 5-step process (Figure 2) in creating report cards:

Step 1: Developing the conceptual frameworks to understand ecosystem processes, environmental values and threats, et cetera
Step 2: Choosing indicators that can be measured
Step 3: Defining thresholds to establish benchmarks; a color-coding scheme of green–yellow–red is used to convey scale of values
Step 4: Calculating scorecards, by combining different indicators and presenting them in a way that makes sense to decision makers, resource managers, and the public
Step 5: Communicating results through mass media with supporting material in technical or Web-based venues (Costanzo et al. 2017).

Four foundations for the report card were essential in its creation:

1) The report card was to be built in the basins: The report card would gather data and provide grades at the scale of the 5 basins (Upper Mississippi River, Ohio River, Lower Mississippi River, Arkansas and Red rivers, and the Missouri River) through multiple workshops that served as third places and through integrating the results to create the watershed report card.
2) The report card was to be built with partners: The report card development process would recruit leading stakeholders and partners in each of the 5 basins who in turn would help to recruit stakeholders to participate in workshops and meetings to provide the foundational information for the cocreation of the report card.
3) The report card was to be built with diversity: The report card needed to have active engagement from a diversity of stakeholders and perspectives including business; basin associations; civic organizations; local, state, and federal governments; academic institutions; and others.
4) The report card was to be built with transparency: The report card data sources, methodology, and evaluations would be shared with the participants and public to allow for review and feedback while under development and after completion.

The last 3 foundations were achieved through the co-development of boundary objects, creating information products that are salient, credible, and legitimate.

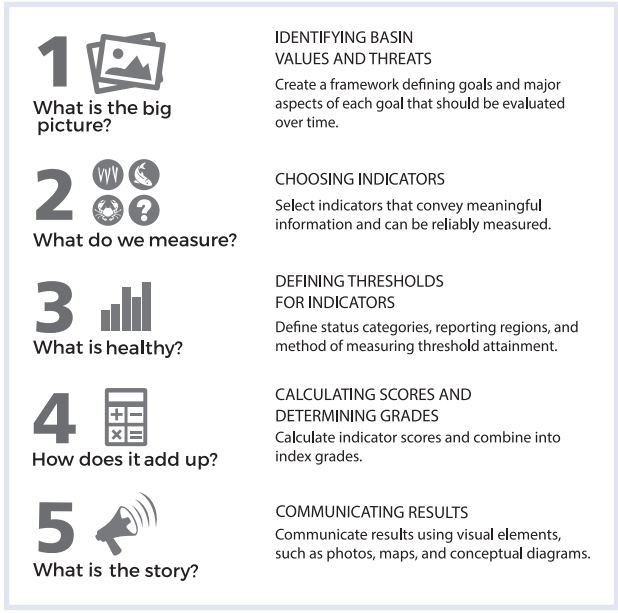

Figure 2. The University of Maryland Center for Environmental Science Integration and Application Network follows a 5-step process when developing report cards.

DEVELOPING THE MISSISSIPPI RIVER WATERSHED REPORT CARD

The report card process emphasized active participation through an open process of engagement, exchange, and collaboration with stakeholders who crossed jurisdictional and organizational boundaries in order to address key issues in the Mississippi River watershed. Frequent communication and active participation were facilitated through the development of boundary objects such as conceptual diagrams, workshop newsletters, and the report card product.

Stakeholder selection and engagement

Report card development was guided by several important transdisciplinary principles, which were intended to achieve the most diverse stakeholder input and active engagement possible. The report card incorporated information and advice provided by leaders, stakeholders, and experts from more than 400 businesses, organizations, agencies, and academic institutions from every major river basin in the watershed and from key stakeholder groups (Figure 3). More than 700 diverse participants participated in workshops, summits, webinars, and meetings to gather data, provide feedback, and give advice throughout the process. This allowed the project to be guided by a shared vision for the Mississippi River watershed with an open line of communication for active exchange of ideas and concerns.

Regional workshops

Workshops that served as third places were held in each of the 5 basins to gather information for potential indicators and solicit advice from stakeholders with regional knowledge on the sectors involved in the 6 management goals (Figure 1). Transdisciplinary and participatory processes require skilled facilitation performed by boundary-spanning organizations

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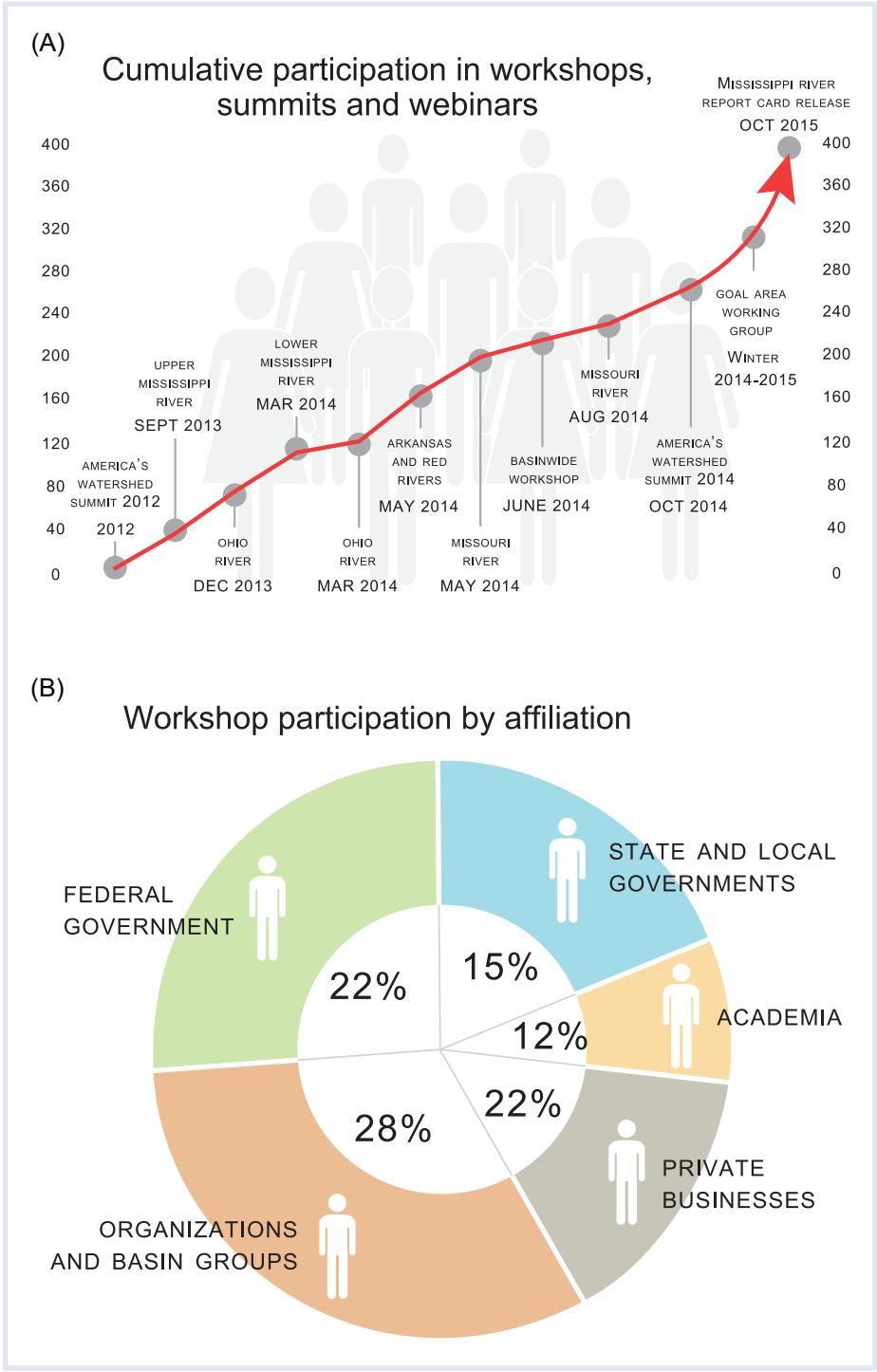

Figure 3. The Mississippi River Watershed Report Card (IAN 2015a) was built with partners and with diversity. More than 400 organizations were engaged throughout the development of the report card (A). These participants represented stakeholder groups from the federal, state, and local governments and agencies, private businesses, academic institutions, and various organizations from every major river basin in the watershed (B).

(Reed 2008; Scholz and Steiner 2015; van Kerkhoff and Pilbeam 2017; Bednarek et al. 2018) and in this case, workshop planning and implementation was coordinated by the AWI staff and facilitated by IAN-UMCES personnel. The workshops included high-level participation from multiple stakeholders from local government units, federal agencies, academia, nongovernmental organizations, and the private sector. These stakeholders were chosen carefully to ensure that each of the 6 management goals and their diversity of issues were well represented through multiple diverse perspectives. The regional workshops were held for 2 d and were characterized by both formal and informal engagement, designed to enhance cooperation and promote knowledge exchange among the participants. Each workshop and

meeting was different, but the importance of the rivers and waters in each basin and from every stakeholder group was clear. After each basin workshop, a newsletter documenting the information gathered was produced.

On the first day of the regional workshops, participants developed a conceptual diagram through participatory mapping. Conceptual diagrams are self-contained visual representations of key ecosystem processes that make use of symbols to summarize the features and threats of an ecosystem (Dennison et al. 2007). This exercise helped foster stakeholder empowerment and product ownership by allowing participants to represent features and processes that are relevant and familiar to them. Participatory maps are planned around a common goal; in this exercise, participants were divided into small groups and were given blank maps of their region. They were then tasked to use their local knowledge and expertise to spatially identify what they value in their region and what they think are the threats that their region is facing. Each map was presented to the whole group and the succeeding discussion served as the basis for the creation of the conceptual diagram (Figure 4). The final conceptual diagram was created using symbols from the IAN Symbols library and underwent several revisions as part of the workshop newsletter. A key component of the conceptualization process is that the facilitated discussion among multiple stakeholders helped synthesize regional issues while developing a shared understanding of these issues and a common language to describe them (Dennison et al. 2007). Further, breaking out in smaller groups builds opportunities for socialization, enhances relationships between participants, and serves as a venue to overcome issues of trust and power inequality (Prell et al. 2010).

Upon development of a shared narrative and understanding through the conceptualization exercise, breakout groups then established a list of indicators that could be used to assess each of the 6 goals. In some of the regional workshops, a new survey tool was used that allowed for each participant to log into a Web interface in order to create a ranked order of preference for each indicator. What is unique about this technology is that different weight was assigned for votes coming from an expert in the specific goal area compared to other participants who have expertise elsewhere. Some indicators were highly preferred, but others were relatively equally ranked. Data availability was discussed and potential data providers were identified.

At the end of each workshop, a newsletter draft was coproduced that featured the basin's conceptual diagram, values and threats, suggested indicators, and a group photo of the participants with their names and affiliations. Finalization of the newsletter took about 4 to 6 wk after each

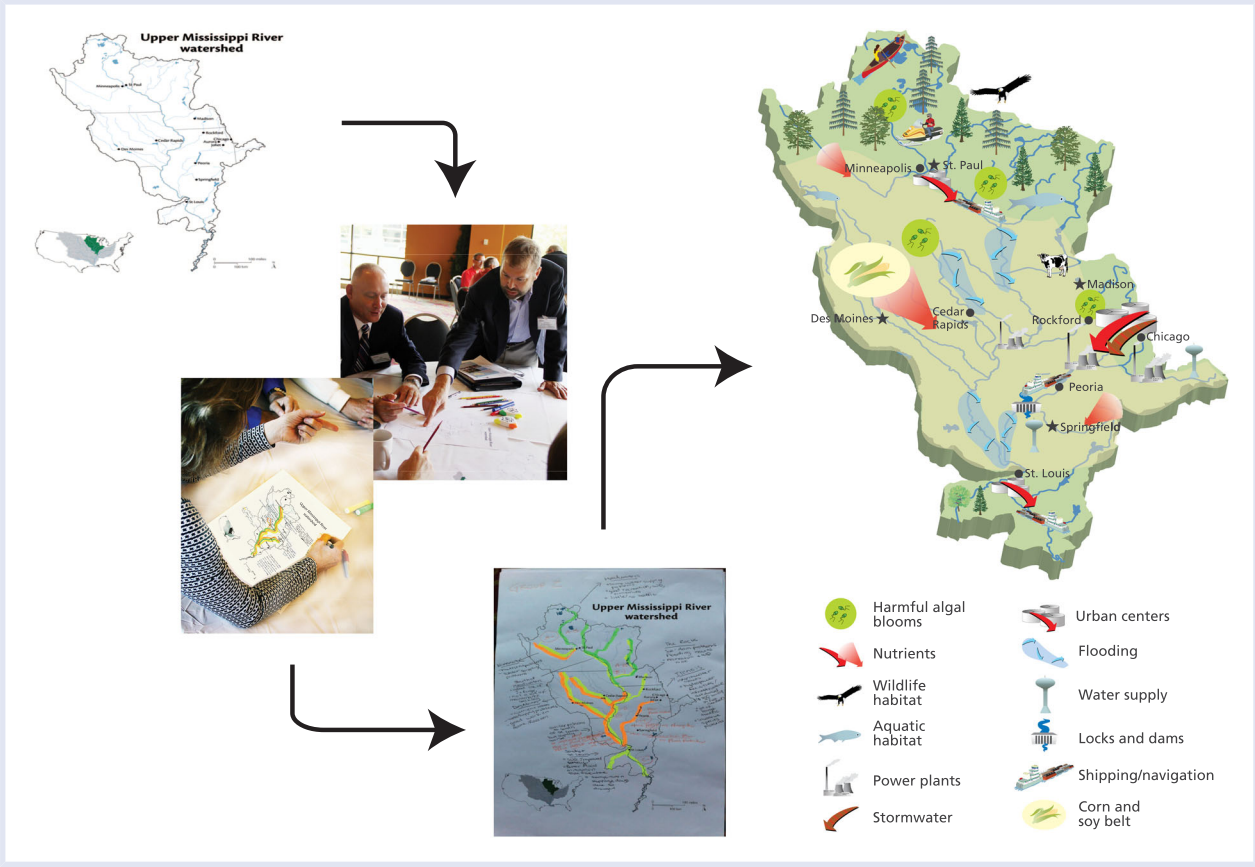

Figure 4. Participants codeveloped conceptual diagrams through participatory mapping. In each of the 5 basins, workshop participants used their regional expertise to map the values and threats of their basin. These conceptual maps served as boundary objects that helped in developing a shared understanding among participants. Symbols used for the final conceptual maps are available at the Integration and Application Network, University of Maryland Center for Environmental Science Symbol library (https://ian.umces.edu/symbols/).

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workshop, with constant engagement of all participants throughout. The newsletters served as documentation of the progress that was made during the workshop, consensus that was reached on the key messages, and the potential indicators that could be used to measure progress toward the 6 goals. At the outset of the meetings, participants were assured that a printed document would be produced that represents their combined efforts.

Some basins (i.e., Missouri, Ohio, and Lower Mississippi) required more than 1 visit to improve stakeholder engagement from that area (Figure 1). For example, because of practical and historical issues, the Tennessee River is often considered to be separate from the Ohio River Basin even though it is a tributary of the Ohio River. Thus, a workshop was held in Nashville, Tennessee in addition to the one held in Cincinnati, Ohio. The series of regional workshops in the 5 basins was concluded with a meeting in Arlington, Virginia to discuss the integration of basin results into the overall watershed results. This meeting built on the results of the regional workshops over the previous year. The meeting also addressed issues that were applicable at the scale of the entire watershed but that were not considered in the individual basin workshops.

In all, more than a dozen major workshops and meetings brought together diverse experts with broad perspectives to help develop the report card. The original intent for the workshops was to identify the measures that would be appropriate for each goal and region by seeking expert opinion and local knowledge to select the indicators that could best reflect the status of the goals. However, it quickly became apparent that the workshops created value beyond that narrow objective. Participants routinely mentioned how unusual and refreshing it was to work together with other stakeholders, sometimes with perspectives very different than their own. The single-issue advocacy model that interest groups have been following for decades had precluded close collaboration prior to the AWI workshop. In addition, the production of the newsletter after each workshop was particularly valuable to the participants because it gave them the feeling that they had already made important progress, and that the time spent at the workshop was an investment in a tangible product that could be disseminated. Because of the regional workshops and the production of newsletters afterwards, there was trust in the cocreation initiative and participants had clear incentive to participate.

Development of the report card

Sustaining the momentum and the collaboration that was formed among the different stakeholders was another important aspect of the report card development process. This was achieved through the cocreation of new knowledge and understanding of the interconnectedness of the different values within the Mississippi River watershed. This integrated knowledge was documented and communicated not through typical scientific publications and project reports but through a report card and a suite of supporting science communication products that served as boundary objects. Unlike traditional scientific publications that generally have restricted access, report cards allow for the delivery of concise, data-driven information in a timely manner to broad audiences.

The development of the Mississippi River watershed report card was done in 2 stages: creation of a preliminary report card and a final report card. A comprehensive methods report (IAN 2015b) that includes the data sources, calculations for each indicator, interpretation, calculation and assignment of scores, and calculation of basin and watershed average scores was also prepared in support of the final report card. A short video that described both the process of producing the report card and the report card scores was also produced. A series of blog posts were also written documenting the experiences throughout the process. In addition, a comprehensive website, https://americaswatershed.org/reportcard/, was created where all the relevant information on the report card can be found. The information generated through the report card process is represented in a pyramid structure: the highly synthetic report card at the top and additional details provided by the basin newsletters, the report card web site, and methods document, all of which are ultimately supported by the primary data (Figure 5). This pyramid structure provides access to information at various levels of detail for different user needs and creates credibility through transparency of data, methods, and results.

Preliminary report card release and the revision process

Indicators for the preliminary report card were chosen on the basis of recommendations from the basin-level workshops and their relevance to measuring the goal, consistency with other basin indicators, data availability, and the ability to develop a relevant scoring method. The report card utilized national, regional, and state level data to report on more than 20 indicators for flood control and risk reduction, transportation, water supply, economy, recreation, and ecosystems goals, in 5 basins within the Mississippi River watershed, as well as key impacts to the northern Gulf of Mexico. Results of the report card were calculated for the Upper Mississippi River, Ohio and Tennessee rivers, Lower Mississippi River, Arkansas and Red rivers, and Missouri River basins, and results from these 5 basins were summarized in an overall watershed score.

The preliminary report card underwent multiple revisions based on the feedback of the AWI Steering Committee, the report card working group, and other key stakeholders. The preliminary draft was presented during the October 2014 America's Watershed Initiative Summit in Louisville, Kentucky. External facilitators organized the meeting as a series of structured interactions designed to solicit constructive feedback about the report card from summit participants. The preliminary results generated many constructive suggestions, which guided a comprehensive revision of report card indicators, data sources, analyses, and presentation. Expert review panels and working groups

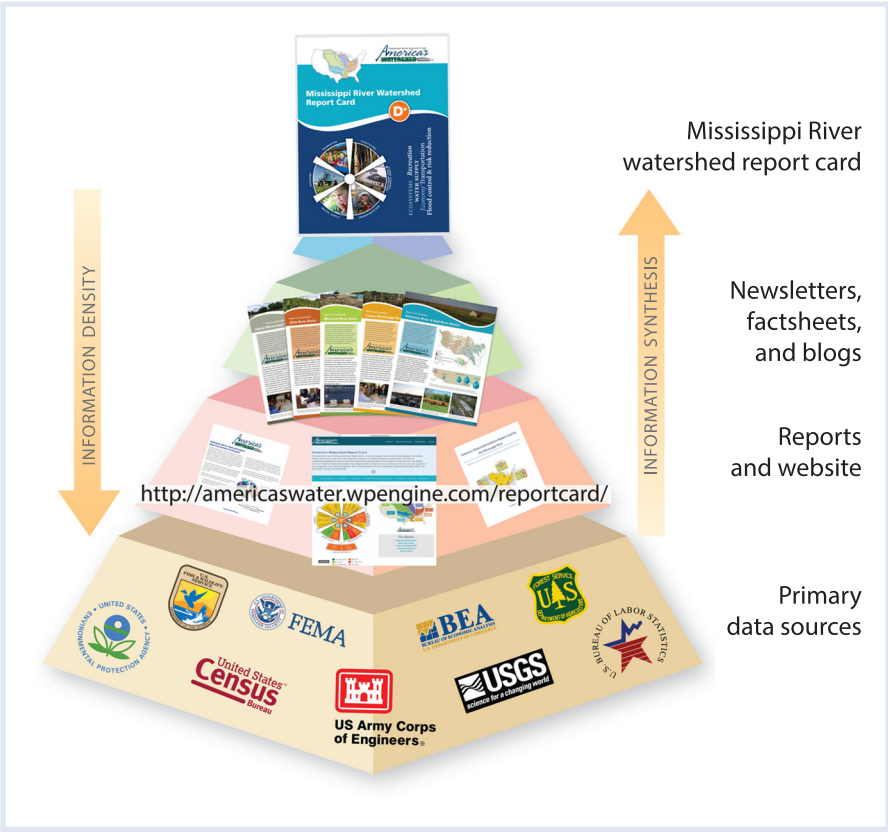

Figure 5. The Mississippi River Watershed Report Card (IAN 2015a) was built with transparency and sits atop an information pyramid supported by primary data sources. The scoring methodologies that were used underwent extensive stakeholder consultations, and expert reviews and were made available through a dedicated website. The results of the workshops, summits, and meetings were well documented through the publication of newsletters, factsheets, and blogs.

were formed to consider more than 250 specific suggestions. Some indicators included in the preliminary report card were dropped, new indicators were added, and all of the scores were recalculated. In addition to the goals and basin results, watershed-wide indicators were also included (Table 1, Figure 6). All measurements were standardized to a 0-to-100 scale to enable aggregation of individual indicator results to the goal score. It is important to note that the scoring scheme is not a reflection of a curve or a lenient grading system; the working group for each goal area and expert advisors determined through data analysis what data values represented good and bad grades, and those were translated to the final scoring scheme distributed into the 0-to-100 scale in 20-point increments.

Release of the final report card

The final Mississippi River Watershed Report Card (IAN 2015a) was released on 14 October 2015 in St Louis, Missouri. About 75 participants from the AWI Steering Committee; US Army Corps of Engineers; municipal, state, and local governments; and academic and nongovernmental organizations involved with the process attended the event. Immediately upon release, the report card generated significant media coverage, including more than 3000 local, state, and national media placements, nearly 3 million Twitter impressions and substantial Web visits to the americaswatershed.org and other sites hosting the information. One key to the media success was the effort to recruit AWI Steering Committee member organizations and partners who collaborated in developing the report to post stories and use social media to advance the report card messaging. Substantial effort was spent prior to the event to work with and engage the different stakeholders to help leverage media outreach. When the report card was released, many of the stakeholder groups also issued press releases and disseminated information through their own networks. The report card release generated substantial media interest and penetrated different media sectors and markets because of the ownership demonstrated by the diverse stakeholders engaged in the development process. For example, press releases from the National Corn Growers Association, and press interviews with the Ingram Barge Company executives and the Waterways Council, Inc., likely generated interest from agricultural and navigation-related news outlets and publications.

The publication of the report card symbolizes the concrete realization of the collective efforts of the various stakeholders that participated in the process. Stakeholders were guided not only by a unified vision for the watershed, but they also actively codesigned the assessment and coproduced the report card, which created a sense of shared ownership of the project outcome.

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Table 1. Indicators used for the Mississippi River Watershed Report Card[a]

Goals	Indicators	Description	Sources of data
 Maintain supply of abundant clean water	Water treatment violations	Percent of the population served by community water systems that did not report any violations in 2013.	2013 Government Performance and Results Act of Total Water Systems
	Water depletion	Water use compared to the total amount of water naturally available from precipitation and stream flow (minus losses from natural evaporation).	2010 WaSSI model results for HUC8 watersheds
 Provide reliable flood control and risk reduction	Floodplain population change	Change in number of people living in areas most at risk for flooding compared to the change in number of people living in a basin.	US Census and FEMA Special Flood Hazard Area
	Levee condition	Status of levees inspected by the US Army Corps of Engineers.	USACE 2013 National Levee Database
	Building elevation requirements	Community adoption of requirements to elevate structures above mapped flood levels.	Association for State Floodplain Managers
 Support local, state, and national economies	River-dependent employment	Number of people employed in river-dependent sectors in each state in 2013 compared to the national average.	Bureau of Labor Statistics 2013
	GDP by sector	GDP for river-dependent industries in each state for 2013 compared to the national average.	Bureau of Labor Statistics 2013
	Median income	2013 per capita income by state compared to the national average.	Bureau of Economic Analysis 2013
 Support and enhance healthy and productive ecosystems	Living resources	Condition of aquatic animal communities living in the ecosystem.	USEPA National Rivers and Streams Assessment 2008–2009
	Water quality	Nutrient (N and P) levels in rivers and streams in the watershed.	
	Habitat index	Condition of stream and river habitat in the ecosystem.	
	Wetland area change	Percent change in wetland area in each basin.	Multiresolution land characteristics data
 Provide world-class recreation opportunities	Outdoor participation	Recent hunting, fishing, and birding activity and national park visitation compared to the 20-y historical range.	USFWS survey by US Census Bureau, and National Park Service
	Hunting and fishing licenses	Recent sales of licenses, tags, stamps, and permits for hunting and fishing compared to the 10-y historical range.	USFWS
 Serve as the nation's most valuable river transportation corridor	Lock delays	Amount of time in 2013 that locks in a basin were unavailable compared to the best performing year between 2000 and 2012.	USACE 2013
	Infrastructure condition	Condition of critical infrastructure at locks and dams.	USACE 2010
	Infrastructure maintenance	Adequacy of maintenance funding for navigation infrastructure on a pass/fail basis.	Office of Management and Budget, USACE, Congressional Research Service, and NRC
 Maintain a functioning, sustainable Mississippi River watershed	Gulf dead zone	Annual maximum extent of the northern Gulf of Mexico's dead zone compared to the restoration goal set by the Hypoxic Task Force.	Mississippi River/Gulf of Mexico Watershed Nutrient Task Force
	Coastal wetland change	Net rate loss of wetland in coastal Louisiana average over the last 11 y.	USGS

FEMA = Federal Emergency Management Agency (US); GDP = gross domestic product; HUC8 = hydrologic unit code and hierarchal designation 8; NRC = National Research Council (US); USACE = US Army Corps of Engineers; USEPA = US Environmental Protection Agency; USFWS = US Fish and Wildlife Service; USGS = US Geological Survey; WaSSI = Water Stress Index.

[a]See the Mississippi River Report Card methods report (IAN 2015b) for comprehensive discussion and citation details for all sources of data.

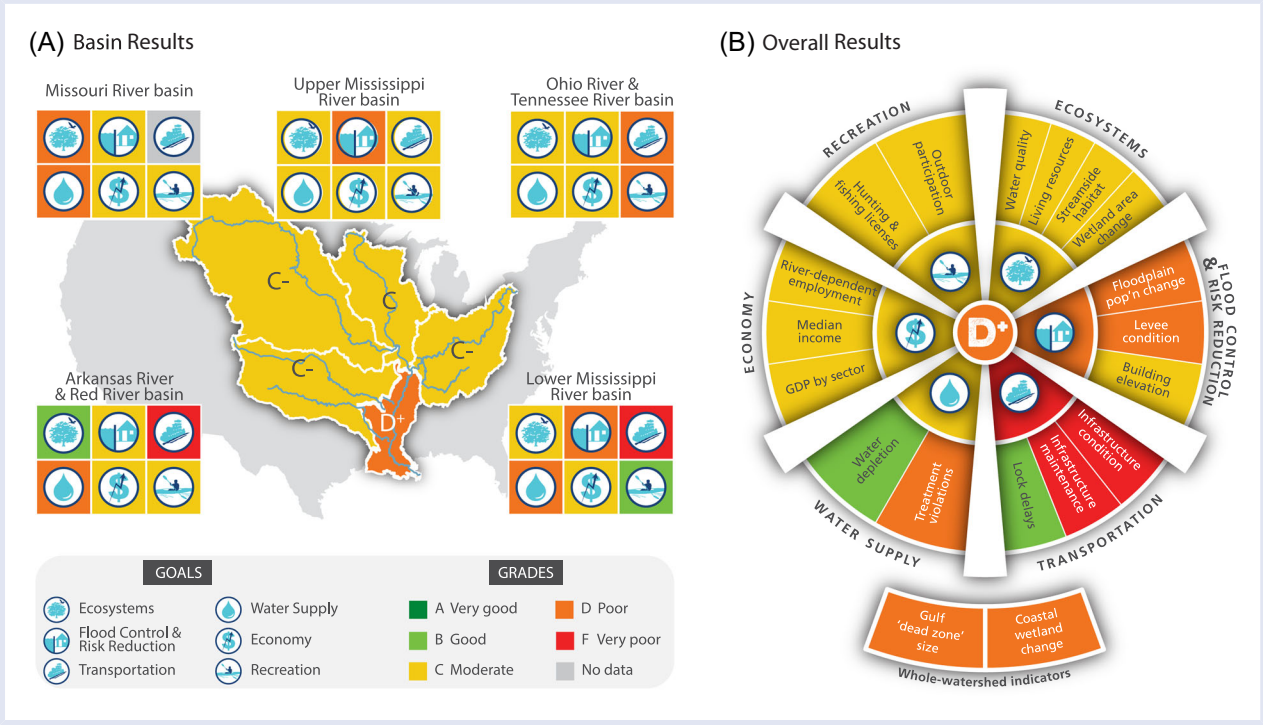

Figure 6. Results of the Mississippi River Watershed Report Card. The report card (IAN 2015a) measured the status and trends of the 6 goals throughout the 31 states and 5 major river basins: Upper Mississippi River, Ohio River, Lower Mississippi River, Arkansas and Red rivers, and Missouri River (**A**). Results from these 5 basins were then summarized in an overall watershed score (**B**). In addition to the goals and basin results, watershed-wide indicators (the size of the Gulf of Mexico hypoxic (dead) zone and the rate of coastal wetland loss in Louisiana) were also included. How scores were calculated is documented in a separate report card methodology report (IAN 2015b). GDP = gross domestic product.

RESULTS AND IMPACTS OF THE REPORT CARD PROCESS

The transdisciplinary process of developing a socio-environmental report card resulted in consensus building and capacity building (Scholz and Steiner 2015). A vision for the Mississippi River watershed, which was shared by participants representing diverse perspectives, was generated. Additionally, the process fostered collaboration and collective action that can lead to more sustainable management of the watershed. This shift to a more integrated approach of natural resource management, which places emphasis on the action of a whole network of individuals and organizations to bring about change, can be referred to as "transformative collective action." It is characterized by 1) development of new knowledge that highlights ecosystem interconnectivity, 2) formation of social networks, 3) emergence of leaders with synthetic and integrative vision, and 4) new opportunities that can bring change (Ernstson 2011).

Creating new knowledge by synthesizing information and identifying gaps

The report card generated awareness of the importance of the watershed and key issues, but also highlighted important knowledge gaps as well as key current and future challenges in the watershed (IAN 2015a). Regional results varied across the watershed, but the Mississippi River watershed earned a D+ overall grade, a poor result (Figure 6). The results revealed several challenges: the transportation, flood control and risk reduction, and the watershed-wide indicators for coastal wetlands loss and the hypoxic "dead zone" in the Gulf of Mexico all received D scores. These results highlighted key issues related to the contribution of nutrients that lead to the Gulf of Mexico hypoxic zone, losses of sediment required to maintain coastal wetlands in Louisiana, the gap in maintenance funding for locks and dams, and areas where populations are disproportionately increasing in the flood plain, creating higher risk for flood damages. Participants in the report card process also cited the need for better coordination among regional programs directed at ecosystem restoration and economic development across the watershed.

The results and information gaps highlighted in the report card were important outputs of the process, which created a common understanding of key issues and data needs in the watershed. A detailed discussion of the report card results can be found in the report card methodology report (IAN 2015b). Key knowledge and information gaps were identified in the report card process. These included needs for the following:

- More spatial, temporal, and methodological consistency in data for water quality, living resource health and diversity, and streamside habitat. Existing data on these factors are either inconsistently analyzed or have poor spatial and temporal resolution.

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- Greater spatial resolution of census data related to populations in the flood plains and understanding of flood damage prevented by control structures. Existing census data are not bounded by floodplain boundaries, and interpolation methods must be used to estimate the fraction of population in census blocks that are within the floodplain.
- Better information related to funding distribution and shortfalls for transportation infrastructure maintenance and repair, and economic impacts of transportation system disruptions. Information on the amount and distribution of funds requested and allocated to infrastructure repair and maintenance is opaque.
- Better information on depletion of groundwater, especially on depletion rates in the Ogallala Aquifer. Water demand shortfalls are made up with groundwater, but little is known about the ability of the aquifer to maintain this shortfall in the long term, especially considering projected precipitation changes.
- Better information linking watershed condition to economic status. Readily available economic data that are not easily disaggregated to generate information relevant to watershed condition.
- More comprehensive information on recreation participation and resulting economic impact. These data are not collected consistently (both spatially and temporally) and can be difficult to access.
- Detailed linkages of regional and coastal nutrient sediment delivery, as well as needs and control options. Nutrient loads to the Gulf of Mexico are too high, creating the hypoxic zone in the northern gulf, and the sediment load is not delivered to wetlands affected by sea level rise and subsidence to reverse the enormous loss of wetland area in coastal Louisiana, especially considering sea level rise projections.

Building social networks and emergence of social leaders

Creating common knowledge in and of itself is not sufficient for successful collective action; generated knowledge must be internalized and shared among community members (Ishihara and Pascual 2009). The AWI's goal is to build and implement a vision based on collaboration and mutually beneficial outcomes in contrast to single-purpose advocacy, while utilizing the strong leadership already present in the Mississippi River watershed. Creating shared measures through the report card prompted partner recruitment and network formation to strengthen the collaboration within the watershed. Enhanced relationships among the stakeholder groups generated during the report card development process were instrumental in creating viable pathways for improving integrated management.

The report card process contributed to increases in social capital within the Mississippi River watershed through knowledge exchange and the social learning that was facilitated through the cocreation of the report card and other boundary objects. Social capital is defined as the "features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" (Putnam 1995). Features of social capital that can increase through social learning include trust; reciprocity and exchanges; common rules, norms, and sanctions; obligations and expectations; values and attitudes; culture, information, and knowledge; and connectedness in networks and groups (Pretty and Ward 2001).

Social learning has the potential to develop new partnerships, strengthen existing collaborations, and even transform adversarial relationships (Schusler et al. 2003; Stringer et al. 2006), and these effects were seen in the case of the Mississippi River watershed stakeholders. Social and mutual learning were enhanced through the establishment of third places and the cocreation of boundary objects. One of the barriers overcome by the report card process, as reported by workshop participants, was skepticism about the ability of a multisectoral approach that could lead to concrete outcomes, given that some participant organizations and sectors are naturally in dynamic tension with each other. The workshops and report card development process created an atmosphere of trust and shared visioning. Through interactive social and mutual learning, individuals are able to learn about the character of other group members and begin to understand and appreciate the legitimacy of each other's views (Stringer et al. 2006).

Seizing opportunities for collective action

For institutional change through collective action to occur, a network of individuals and organizations is needed to continuously share information, unite their collective effort, and sustain the pressure for change (Ernstson 2011). An example of this was seen in the October 2016 "Raise the Grade" conference in Moline, Illinois, which was organized by River Action, Inc., as a response to the score given to the Upper Mississippi River basin in the 2015 Mississippi River Watershed Report Card (IAN 2015a). The conference brought together more than 200 participants from 95 organizations to develop solutions and prioritize specific actions to overcome the many challenges identified in the report card, in which the Upper Mississippi River basin received a C grade. This resulted in an action agenda (IAN 2016) that was released in December 2016 and presented to the US Congressional Representatives for the States of Illinois and Iowa in January 2017. The action agenda identified 7 objectives that address ecosystem resilience, nutrient reduction, monitoring and assessment, watershed planning and management, transportation infrastructure, recreation opportunities, and hydropower. For each objective, specific actions were identified that could be taken to improve conditions in the Upper Mississippi River watershed.

Aside from developing a coordinated and shared action agenda to "Raise the Grade" for the Mississippi River watershed, one of the goals is to achieve collective impact through strategic investments, leveraging the efforts by the different stakeholder groups to improve decision making in the watershed. "Collective impact" refers to collaborative

projects that address complex and intransigent problems through collective vigilance, learning, and action (Kania and Kramer 2013). This process, which is initiated by the development of the Mississippi River Watershed Report Card, requires multiple stakeholders to change their behavior and pursue a shared goal, rather than pursuing the singular objectives represented by their professional perspectives and single-issue advocacy.

The report card has been the focus point for many significant presentations about challenges and opportunities in the Mississippi River watershed. Presentations focused not only on the report card process and grades but most importantly on the opportunities to collaborate to "Raise the Grade" for the Mississippi River watershed. Specifically, different groups want to know how their goals fit with the other sectors in the environment and how the whole system works. Businesses, organizations, and agencies involved in developing the report card continue to work together to seek specific actions to improve the watershed and support efforts to improve the outcomes in the transportation, ecosystem, and recreation goals in the report card. The report card has also been used to support watershed-scale decision making in meetings and presentations to the Mississippi River Commission, USACE, Mississippi River Congressional Caucus, National Oceanic and Atmospheric Administration (NOAA), and many other public and private stakeholders.

CONCLUSION AND RECOMMENDATIONS

The Mississippi River Watershed Report Card represents a significant milestone in the ability to integrate information and perspectives from multiple sectors toward holistic assessment for multiple objectives, in one of the largest and most important river systems in the world. The project leveraged principles of transdisciplinarity by engaging diverse participants in a codesign and coproduction process from the outset of the project, through the creation of boundary objects. Boundary-spanning organizations facilitated the process using principles of knowledge exchange and integration and of social and mutual learning to improve understanding among participants with diverse perspectives and opinions. The report card process created an atmosphere of trust by utilizing third places that fostered new collaborations and partnerships and potential for collective action and collective impact.

The development of the Mississippi River Watershed Report Card satisfied the 5 preconditions for collective impact (Kania and Kramer 2011). The collective impact model requires a shared vision for change that is developed through an inclusive process involving all stakeholders, a common system of measures to assess progress toward achieving goals, mutually reinforcing activities, continuous and open communication, and backbone support. The workshops, the newsletters, the report card as the ultimate product, and efforts to raise the grade provided rallying points for working together, creating a common vision, common measurements for progress, a common language, and a new level of trust among the participants. The AWI and UMCES-IAN served as backbone support by coordinating and facilitating the process. To make collective impact work, however, it is important to establish a long-term regional "home" for the report card that can continuously and consistently function as a backbone organization and provide 6 essential functions: guide overall strategic direction, facilitate dialogue between partners, manage data collection and analysis, handle communications, coordinate community outreach, and mobilize funding (Hanleybrown et al. 2012). The AWI is taking on this role, as it is currently leading the effort to update the report card, with the expected release in 2020.

Additionally, the report card results highlighted key issues that are important to sustainable management of the watershed and identified important information gaps and data needs. Data quality, consistency, and availability are major issues in such a large regional assessment. Assumptions about data utility were challenged and required flexibility and revision of assessment methods to account for best available and surrogate data. Data useful for supporting holistic decision making over the entire watershed and across multiple sectors are simply not adequate in some cases. The report card was specifically created at the scale of the Mississippi River watershed and the 5 major basins within it, but most citizens experience conditions at the scale of small streams and watersheds, and state, local, and county administrative boundaries. Thus, improving the resolution of report card results could allow for more locally generated data to be used, increasing their relevance. Data at this scale were not used in this first report card largely because they were not consistent across basins. There is also a need to explore the intricate linkages between report card goal areas and between indicators within goal areas. Exploring these linkages will improve understanding of actions that could improve the status of multiple goals.

It is also important to create a pathway to better leverage the report card process to generate collaborative action and collective impact to improve holistic management. An important next step is to increase our understanding of the social networks within the Mississippi River watershed and use this understanding of social dynamics to influence management and identify local leaders. It is important to actively maintain and seek out diversity in knowledge and viewpoints, especially in natural resource management where development of alternative options is crucial (Prell et al. 2010). However, selecting stakeholders from different organizations, categories, or sectors might not be enough. Rather, it is the existing social network or the structure of social ties between individual stakeholders that potentially plays a bigger role (Prell et al. 2010). There is a need to evaluate regional participant networks and identify potential collaborations that can be leveraged to create collective action and identify potential collaborative opportunities.

The process of creating the first-ever report card for the Mississippi River watershed built a foundation for collective

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action by creating a shared understanding of, and vision for, the Mississippi River watershed. The process reinforced the importance of stakeholder engagement at all stages and the utility of high-quality data and effective communication for decision makers. It also provided access to information at various levels of detail for different user needs and created credibility through transparency of data, methods, and results. The multistakeholder-driven process created the opportunity for engagement of multiple users, managers, and researchers throughout the 5 basins on prioritizing issues using third places and cocreating boundary objects. This process allowed for high-level visioning across disciplines and interests, which supports the idea of transdisciplinary activity to implement solutions. This process of developing a report card through transdisciplinary collaboration can be used in any system and can provide the foundation for collaborative solutions by creating a holistic assessment that incorporates multiple perspectives from multisectoral actors.

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Open Materials Badge—This article has earned an Open Materials badge for making publicly available the components of the research methodology needed to reproduce the reported procedure and analysis. The materials are available at https://ian.umces.edu/pdfs/ian_report_577.pdf. Learn more about the Open Practices badges from the Center for Open Science: https://osf.io/tvyxz/wiki.

Data Availability Statement—The sources of data used in the calculation of the Mississippi River watershed report card scores are publicly available and identified in Table 1 of this manuscript. A white paper describing the methodology used in the calculation of scores and discussion of report card results is available online (https://ian.umces.edu/pdfs/ian_report_577.pdf). Record of numbers of workshop and webinar participants, names, and organizational affiliation is available from the authors and/or the America's Watershed Initiative. Social media impressions reported in this manuscript are from GreenSmith Public Relations, a public relations and business development firm based in the Washington, DC area that was contracted by the University of Maryland Center for Environmental Science to help during the final release of the Mississippi River Watershed report card.

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