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Restoration as social-ecological transformation: Emergence in the Pike River Watershed

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ABSTRACT

The combined effects of urbanization and climate change require resource managers to navigate interacting social and ecological dimensions of environment in the stewardship of ecosystem goods and services. The challenge of integrating multiple management paradigms into the planning process for sustainable restoration is complex, yet when handled successfully, can result in the emergence of ecosystem goods and services. The present study uses the restoration of the North Branch of the Pike River in Southeastern Wisconsin, USA as a case study to understand the contributions of situational context and actor agency in the integration of management paradigms, and transformation of a highly degraded stream ecosystem into a vibrant community asset. Drawing from the social-ecological systems and dynamic systems change literatures, the management and transition framework was used to analyze the 20-year restoration process from problem definition and planning through implementation. Review of planning documents, meeting notes, and interviews with key individuals identified the factors necessary to understand how a social-ecological system navigated through conflict, negotiation of an integrated management paradigm, implementation, and adaptive learning. As convening contexts changed, different actors assumed convening, bridging, sense making, and leveraging roles as legitimacy and trust in the process was built over time. Integration of paradigms was identified as a learning opportunity, as the incorporation of diverse ways of knowing resulted in the emergence of novel ecosystem goods and services. The performance of the novel integrated management paradigm since completion is discussed, including takeaways managers should keep in mind when applying the approach elsewhere.

Introduction

As communities continue to address the unforeseen effects of development, the social dimensions of ecosystem restoration have become integrated into the process of project planning and implementation (Moreno et al., 2014; Reed and Bruyneel, 2010; Reed, 2008). This comes from a myriad of directions including a need for equity and environmental justice (Lemos and Agrawal, 2006), an understanding that community values play an integral role in achieving sustainability (Horlings, 2015), and a recognition that relationship building among stakeholders can provide opportunities for social learning and problem solving (Mollinga, 2010; Pahl-wostl et al., 2007; Tress et al., 2005). With the uncertainty and risk surrounding climate change increasing the probability of conflict with competing interests, boundary work and bridging functions are becoming a necessary prerequisite to properly plan and implement projects that meet both ecological and societal needs in an inclusive manner (Stewart and Tyler, 2019; Williams, 2015). However, attempts at co-management face an uphill battle as approaching project planning from a collaborative perspective requires stakeholders to integrate the diversity of management paradigms present in order to reach consensus on a way forward (Halbe et al., 2013; Rockström et al., 2014; Sendzimir et al., 2008). If successful, this approach to restoration has the potential to transform landscapes, allowing communities to define and take ownership of the ecosystem goods and services that emerge from the process (Chapin et al., 2009; Olsson et al., 2004).

The fields of social-ecological systems (SES) and systems change research have made great strides in understanding the necessary and sufficient conditions for transformation in complex social ecological systems. By focusing on the interactions between social and natural systems (Ostrom, 2009a), identifying key stakeholders across scales of governance (Reed et al., 2009), and understanding the diversity of management paradigms present (Halbe et al., 2013), SES assessments have been able to identify and successfully navigate the obstacles that result from the misalignment of administrative and ecosystem boundaries (Galaz et al., 2008; Walker,

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2012). Three attributes that have proven to be essential for transformation in SESs are the establishment of trust among stakeholders, policy leadership, and institutional capacity to legitimize the emergent form of governance (Olsson et al., 2007).

Trust has proven to be an important attribute of common pool resource governance through both behavioral experiments and in depth field studies (Ostrom, 2009b). For instance, a set of irrigation dilemma simulations found that the interplay of trust, investment, and extraction in the first round of trials was the defining factor in determining user behavior for the remainder of the experiment (Baggio et al., 2015). Studies of water users in the Sacramento River Watershed in California identified familiarity as a significant factor in establishing trust. Elevated levels of trust were identified between local water users and regulatory agencies they more frequently interact with compared to more centralized organizations (Lubell, 2007). Taken together, these findings suggest that breeding trust requires resource managers to be both cognizant of initial conditions and intentional in establishing processes that call for repeated interaction where decisions can be made collaboratively.

Recent research into leadership has re-defined the term from the ubiquitous attribute of driving change, to one that is plastic, context dependent, and focused on identifying opportunities and individuals to facilitate change (Plowman et al., 2007; Rayner and Bonnici, 2021; Wenger-Trayner and Wenger-Trayner, 2021). Shifting systems to promote healthier outcomes requires capacities to engage with and value multiple perspectives, to identify and visualize interactions among diverse interacting factors in the system, and when necessary to question the boundaries that have been drawn around what is considered the scope or focus for how a system is defined (Williams, 2014). To this end, there are several ways in which individuals or groups can exhibit leadership in environmental governance contexts. A review of the literature on leadership in the environmental sciences identified different styles of leadership including adaptive, collaborative, process oriented, systems thinking, and visionary (Evans et al., 2015). These leadership styles become especially important in cross-sectoral collaborations where creating shared meaning is necessary to define the problem at hand and ensure buy in from all parties involved (Crosby and Bryson 2010; Rayner and Bonnici, 2021).

Although trust and leadership are integral to transformation in SESs, there must also be sufficient institutional capacity to incorporate the changes made to the system (Green et al., 2015). When attempting to understand the emergence of a resilient set of regulations in the Maine Lobster Fishery, it was found that policies well founded in science may fail if they are not accepted by those involved in utilizing the resource (Acheson, 1997). Additionally, any changes to resource governance must be in compliance with established laws and regulations in order to be legitimized by larger scales of decision making (Amsler, 2016). It is therefore necessary that an understanding of the interconnected ecological, social, and legal systems is established for transformations to be successful. Trust, leadership, and institutional capacity are all highly context dependent attributes that contribute to the outcome of any specific situation in SESs. It is well established in the literature that the attributes and competencies of actors involved in environmental governance can be of critical importance in determining the success or failure of collaboration or collective problem solving (Berardo and Scholz, 2010; Fischer et al., 2016; Henry, 2020).

This study combines both SES and systems change approaches to understand the contributions of context and agency in the transformation of the Pike River Watershed in Racine, WI, USA. More broadly, this hybrid approach is used to answer the question 'how can restoration serve as process to integrate multiple management paradigms and result in emergent ecosystem goods and services?'. To accomplish this, the restoration process was analyzed using the management and transition framework (MTF), a well-established method in the SES literature which conceptualizes change in governance regimes (Pahl-Wostl et al., 2010), to analyze the actions of individuals and identify the management paradigms present. This method was then adapted to include themes from systems change research to provide context to the processes resulting in the emergence of novel ecosystem goods and services. We begin this case study with a brief history of the Pike River Restoration Project followed by a methods section that introduces the MTF and how meeting notes, plans, reports, and interviews were analyzed for the system. We present the results utilizing the adapted MTF method along the timeline of Pike River restoration's process from initial need and planning to implementation and maintenance. The discussion section focuses on the importance of context, roles, and learning in the transformation of ecosystems, and the conclusion briefly discusses how this process could be implemented in other contexts.

Social-ecohydrological context: a brief history of the Pike River watershed

The Pike River Watershed, Racine County, Wisconsin is situated on the southwest coast of Lake Michigan (Fig. 1). Vegetation in the watershed prior to European colonization consisted of prairie, oak savanna, maple-basswood-red oak forests and wetlands, supported by soils developed over the broad flat areas of glacial till and outwash plain deposits, with an estimated landcover of 67% prairie and 6% wetland out of a total watershed area of 32,708 acres (13,247 ha) (SEWRPC, 1983). The Pike River was most likely characterized by complex channel morphology in the headwaters that contained diverse warm and cool water fish communities. The ecological structure and functioning of this system were intimately linked to physical and hydrological connectivity with riparian and floodplain wetlands.

Following European colonization the watershed experienced multiple iterations of land use change, beginning with agricultural development to support growing urban centers in the 1870s to accelerated economic and suburban development following the second world war (SEWRPC, 1983). The Mount Pleasant Drainage District began activities in October of 1878 when farmers in the Town of Mount Pleasant met to design a plan to increase tillable acreage and reduce flooding on farmed fields by ditching the shallow swale and wetland complex through their farms. Initially the local water table in the swales and wetland areas was at or very near the ground surface. Drain tiles were added into the fields to remove water and transport it to the excavated ditch. Over time, maintenance of the channel, erosion and additional ditching served to lower the groundwater elevation by more than 3 m in locations adjacent to the channel. By 1996, SEWRPC estimated that only 44 of the original 2000 acres of wetland remained as remnants proximal to the North Pike River. Most remaining wildlife habitat was severely degraded, with 105 acres of Class III habitat, 64 acres of Class II habitat, and only 10 acres of Class I wildlife habitat the North Pike Watershed (Mount Pleasant Stormwater Commission, 2015).

The changes in the water table and floodplain caused by channelization in combination with increased surface runoff due to development resulted in higher in peak discharges, sediment loading and water temperature fluctuations, which in turn contributed to decreased habitat heterogeneity and disrupted seasonal flow regimes required for the successful reproduction of keystone native fish species such as northern pike, *Esox lucius*. The physical habitat conditions and biotic communities had degraded to a status typical of channelized river systems in mixed urban/agricultural landscapes (Karr, 1999), and this loss of aquatic ecological

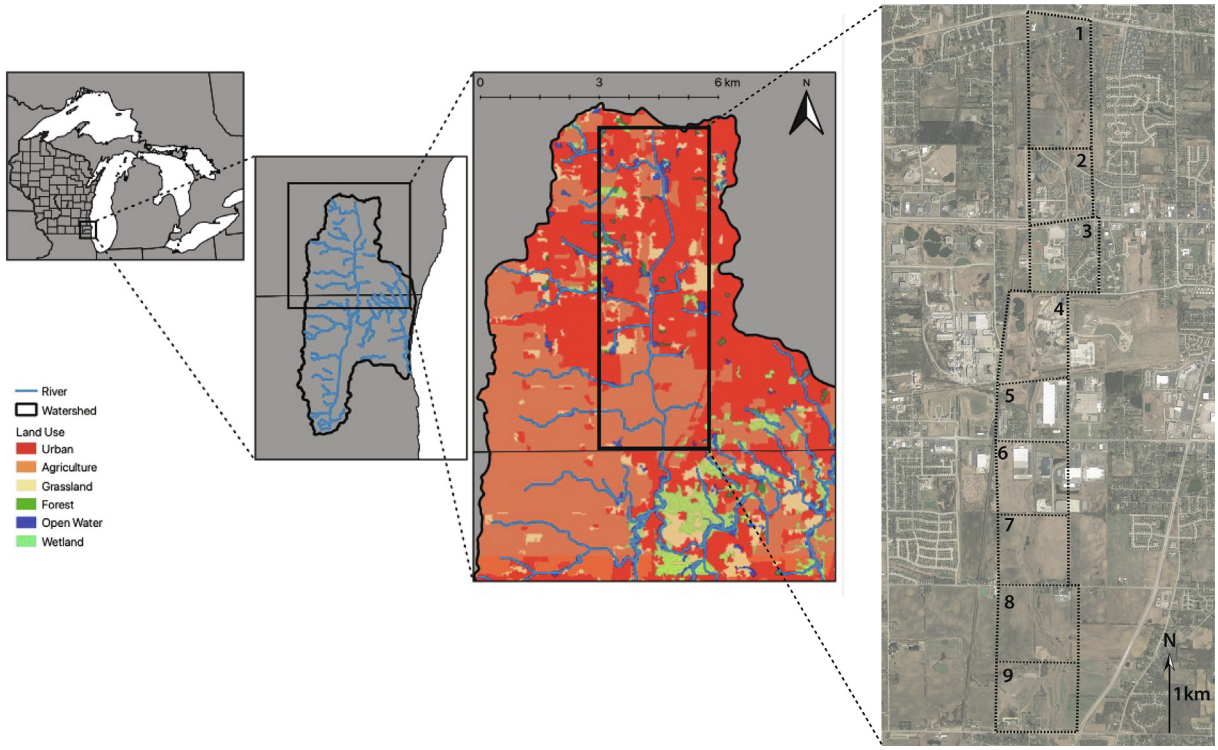

Fig. 1. The Pike River Watershed in Southeastern Wisconsin, USA, including magnification of the restoration phases along the North Branch of the Pike River.

integrity negatively impacted the lower river and the adjacent regions of the Lake Michigan coastal zone.

The frequency and severity of flooding events resulting in property damage increased over time in the upper Pike River as development in the watershed expanded during the 1970s. In 1992 the Town of Mount Pleasant (the Town) prepared and submitted a flood control plan to the Wisconsin Department of Natural Resources (WDNR) for regulatory approval that included channel modifications and in-line storage basins to increase both stormwater conveyance and retention capacity to prevent flooding in downstream reaches of the river. This plan was prepared based upon a 1983 comprehensive watershed study and planning document for the Pike River watershed prepared by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). An environmental impact statement (EIS) was completed in 1995 (Wisconsin Department of Natural Resources, 1995) and the permit request was denied in 1997 due largely to the plan's reliance on extensive streambed dredging to solve flooding issues and negative impacts on ecological integrity of the river ecosystem.

In response to the permit denial the Town sought and retained legal counsel to advance a court challenge the WDNR decision, claiming that they had followed WDNR approved plans beginning with the 1983 SEWRPC report. The court challenge was in process of moving to the Wisconsin Supreme Court when the Town's legal counsel persuaded them to enter a facilitation process with the WDNR to attempt to resolve the challenge out of court. The WDNR provided an outside facilitator with the objective of the facilitation to explore options to mitigate flooding in the North Branch of the Pike River while simultaneously addressing the WDNR's ecological concerns. The Town's legal counsel worked to identify and recruit a team of experts in stormwater management, flood control planning, and ecological restoration to represent the Town's interests in the process. WDNR provided the outside facilitator and was represented by a team individuals drawn various WDNR offices and bureaus. The facilitation process took place over a 6-month period and resulted in a reformulation of the Pike River Plan from a strictly "stormwater convey, store, and release" project into a more integrated stream "riparian corridor and floodplain restoration" project. The conceptual design resulting from the facilitation an approach to the restore approximately 5.2 miles (8.3 km) of stream corridor included the following features:

- Continued comprehensive stormwater and non-point source management to reduce peak flows, maintain base flows, and improve water quality;
- Placement of multiple wetland systems with connectivity to the channel to function as detention/retention basins along the stream;
- Incorporation of multi-stage channel cross-sectional designs with prairie/wetland riparian vegetation to restore the native pre-settlement flora of the watershed;
- Widening of the floodplain to allow more frequent flooding and the dissipation of peak flow energy;
- Increased channel length by addition of sinuosity (meanders) into a new channel in order to diversify habitat;
- Construction of new channel segments outside of the existing streambed when possible – minimizing disturbance to stream and allowing re-vegetation and stabilization prior to use;
- Design and placement of habitat structures to promote resident fish communities;
- Implementation of monitoring plans for habitat, invertebrate, and fish to evaluate the success of the project and recommend modifications as necessary.

Working with these agreed-upon concepts, a team of consultants developed a more detailed 9-phased plan (Fig. 1) with an estimated cost of $17.9 million that was submitted for regulatory approval. A Chapter 30 Permit was issued in 1998 for an initial 10-year period and subsequently was extended for an additional 5 years in both 2007 and 2012. This unique permit included 55

conditions to be met and required WDNR review for the 50%, 90%, and 100% plans for each of the 9 construction phases. Additional US Army Corps of Engineers Section 404 and Racine County conditional use permits were obtained, and a Peer Review Report for the plan was conducted in 1999 prior to the initiation of Phase 1. Construction on Phase 1 began in 2001, followed by subsequent Phases moving from upstream to downstream with the 9th and final phase completed in 2017.

Study context: community-engaged emergent ecosystem goods and services

It was unique that a Chapter 30 permit was issued for a plan that included so few specifics, as captured by the lead WDNR attorney's rhetorical question during the facilitation, "You're telling me that the devil will keep himself out of the details?". A key aspect that resulted from the facilitation process was its reliance on trust among the parties involved that beyond the specific objective of flood control, they would continue to adhere to the broader goals of seeking opportunities whenever physically and financially possible to include aquatic habitat improvement, environmental corridor expansion, multi-use recreational trails and public open space in each of the 9 phases of the restoration. The process of iterative design and review agreed to be conducted for each of the 9-phases of the project established a culture of experimentation, learning and adaptation. As a result, over twenty years The Pike River Corridor developed into a natural and recreational asset with benefits far beyond flood mitigation (https://www.mtpleasantwi.gov/2325/Pike-River-Improvements-Project). An ever-increasing number of citizens hike and bike on the trails (https://www.mtpleasantwi.gov/2250/Pike-River-Pathway) and local schools use the restored prairies and wetlands for educational activities as a "Living Laboratory." The abundant birds, fish and wildlife provide the community with an opportunity to re-connect with the natural wonders re-establishing in the Pike River.

As the restoration neared the final phases of construction in 2014, the Mount Pleasant Stormwater Utility Commission undertook creation of a long-term maintenance plan for the North Branch of the Pike River (Mount Pleasant Stormwater Commission, 2015). Part of this plan included public meetings, focus groups, and key informant interviews to gather public input on their interests, concerns, and desires for the corridor. Additional interviews were conducted in 2018 after the full completion of the project. The Long-Term Maintenance Plan was intended to gain a better understanding of stakeholder values and perceptions of beneficial uses and impairments in the corridor and to promote stakeholder engagement and foster ownership in the stewardship of the watershed and surrounding area. The feedback received from stakeholders in the development of the Long-Term Maintenance Plan revealed that community members perceived numerous benefits from the corridor restoration beyond flood control and aquatic ecological integrity. These community-identified benefits and their interrelationships were summarized in a flow diagram (Fig. 2) that visualizes the emergent social, cultural, and economic goods and services that developed beyond the biophysical restoration activities.

Methods

To understand the emergence of an integrated water management paradigm and associated ecosystem goods and services in the Pike River Social-Ecological System (Pike River SES), an adapted version of the MTF was utilized. The MTF was developed to analyze the complexities of water management and governance with recent applications investigating the effect of water manager's mental models on problem definition and action in water governance (Lerner et al., 2018). Rooted in the institutional analysis and development (IAD) framework, the MTF utilizes the action situation as its focal unit of analysis where participants with diverse preferences interact, exchange goods and services, solve problems or develop new rules (Pahl-Wostl et al., 2010). However, where the IAD's main focus is the evaluation of alternate institutional arrangements (Cole et al., 2019), the MTF attempts to incorporate an actor-centric approach to understand how groups of individuals negotiate about a specific problem.

As initially developed, the MTF has been used to understand the current state of water management systems and identify how to best optimize them towards sustainability. To gain insights into how processes toward sustainability occur requires linking action situations, where participants from diverse backgrounds deliberate over resource management (see Ostrom, 2009b), through their outcomes (formal or informal institutions, knowledge, or operational outcomes; Pahl-Wostl et al., 2010). Through understanding the influence of linked, adjacent action situations, important distinctions can be made as a process plays out and endogenous rules evolve and change (McGinnis, 2011).

Work aimed to fill this gap by outlining a method to utilize the MTF to 'visualize pathways' to sustainable water management (Halbe et al., 2013). In this case, the technique was used as a form of process tracing to understand why a particular governance process succeeded or failed in achieving its stated goals (George and Bennet, 2005). Through elicitation and analysis of management paradigms present in the SES, the technique outlined by Halbe et al. (2013) can map out processes such as conflict, facilitation, and learning. Application to the Pike River SES required the identification of key actors and action situations as well as the resulting knowledge, institutions, and operational outcomes from their interaction. See Table 1 for a list of elements in the MTF and their associated definitions.

In the present study, the approach was modified to illuminate how context and agency affect the transition toward an integrated water resources management paradigm. As outlined in the MTF, the role assigned to an actor is related to the action situation and activates situated knowledge within that context (Pahl-Wostl et al., 2010). Viewing participants in the Pike River restoration project as actors serving roles will help identify how individuals activated their agency to make the transition possible. In addition, gathering information on how the context shifted provides insights into how roles and relationships changed over time. The thinking behind this approach is that while engaging a representative diversity of stakeholders may be a best practice to achieve outcomes reflective of the values of effecting and effected parties (National Research Council, 1996), navigating transitions in social-ecological systems requires individuals to possess context dependent agency (Westley et al., 2013).

To gain a holistic understanding of the Pike River SES's transition to integrated water management, data came from a diversity of sources including:

- Meeting notes from facilitation and preparation of plan resubmittal
- The Chapter 30 Permit Re-Submittal to the WDNR
- Analysis of planning documents including the original 1983 Pike River Watershed Plan (as well as the 1986 amendment), technical reports completed during the restoration process
- Meeting notes and emails related to meetings during preconstruction and construction of each project phase
- Focus group and interview data from the development of a long-term maintenance plan in 2015
- Interview and survey data from key players in the Pike River SES conducted in 2019

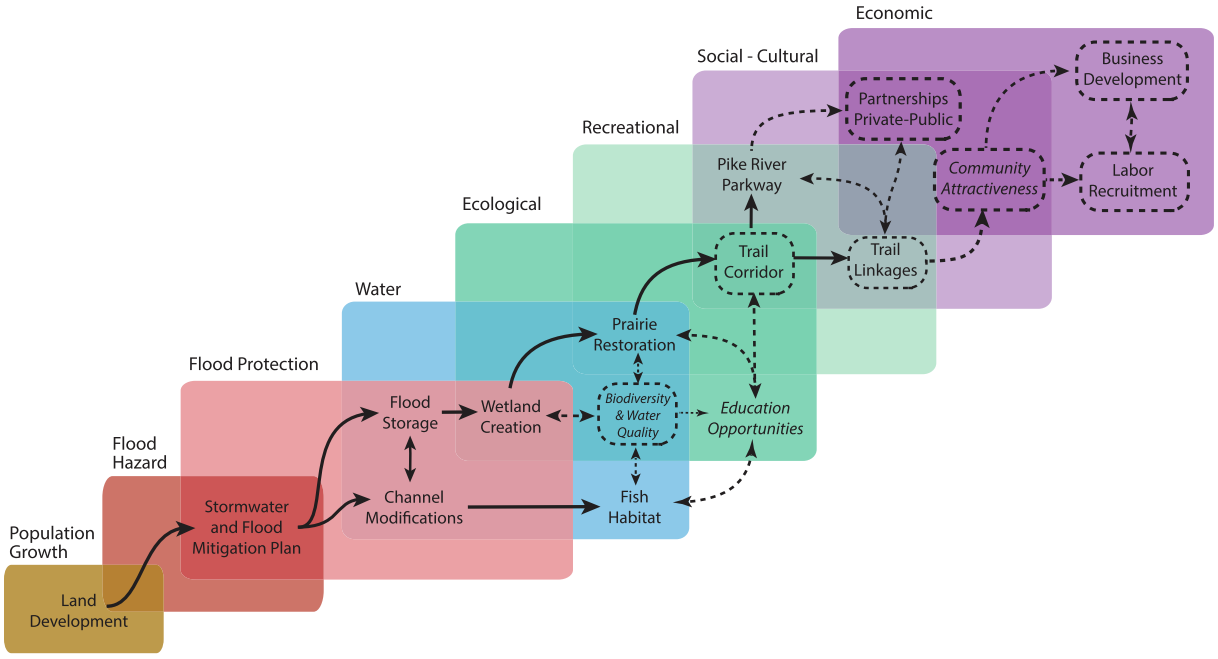

Fig. 2. Pathway of Emergent Ecosystem Goods and Services across the duration of the restoration of the North Branch of the Pike River. Solid arrows indicate the order with which structural components were included into the development and design of restoration plans. Dashed lines indicate components and linkages that were not included as objectives of the restoration plans, which were identified by community stakeholders as important services provided by the completed corridor restoration. Figure is adapted from the Pike River Corridor Maintenance Plan (Mt. Pleasant 2015) and Pike River 2019 Monitoring Report (Mt. Pleasant 2019).

Table 1
Elements and their operational definitions used in the analysis of emergent ecosystem goods and services in the Pike River Corridor Restoration. Element names and definitions follow Pahl-Wostl et al. (2010) with the exception of Convening Context, which was adapted by the authors from Wenger-Trayner and Wenger-Trayner (2021).

Element	Definition
Actor	An individual or collective participant populating an action arena
Role	An actor-based trait based on a shared understanding of an individual's meaning and function within a specific action situation
Action Situation	A structured social interaction that leads to specific outcomes including knowledge, institutions, and operational outcomes
Institution	A societal construct containing a set of rules that may be formal (laws) or informal (norms)
Knowledge	Meaningful information produced in the context of action situations
Operational Outcome	Physical or societal changes which affect the way in which a water system is managed
Management Paradigm	Set of guiding assumptions that determines management actions
Convening Context	A complex systems-based problem where key actors decide to accept the iterative and less-predictable nature of social learning as they collectively explore how to make progress

Data were coded using framework analysis (sensu McGuire and Ehlinger, 2018) to identify the diversity of existing and developing management paradigms throughout the restoration process as well as the elements of the MTF outlined in the visualizing pathways method. The present study provided the addition of roles played by actors in specific action situations which drove the process forward. Relations between elements were based on the sequential order of events and overall pathway, including operational outcomes and emergent properties, of this process using methods adapted from Outcome Harvesting (Wilson-Grau and Britt, 2012) where relationships were substantiated through a series of systems mapping projects administered in graduate classes taught at the University of Wisconsin-Milwaukee from 2013 to 2020 where the Pike River restoration was used as a case study.

Results

Through our analysis of the Pike River SES, a total of 30 factors were identified which made up the visualized pathway to integrated water management (Table 2). Four convening contexts brought actors together to engage in four action situations surrounding the Pike River restoration project. A total of seven actor groups adhering to four distinct management paradigms participated in these action situations, resulting in three operational outcomes, three institutions, and two forms of knowledge. To produce these operational outcomes, institutions and knowledge required actors to take up four distinct roles which varied across action situations and convening contexts. Interactions between these elements, laid out over time, can be found in Fig. 3. The overall process was divided into 3 eras of plan development and implementation and which, along with the convening contexts, will be used to frame the remainder of this section.

Initial plan development and conflict (1983–1996)

Shifting paradigms – protection from the river vs. embracing the corridor

The start of this process involved typical actors in the action situation of initial Chapter 30 permit preparation and submittal. SEWRPC's 1987 amendment outlined how reduction of flooding around the Pike based on the stormwater conveyance management paradigm would call for a widening and deepening of the channel to convey stormwater flows efficiently through the village's stretch of the river. In line with the dominant paradigm at the time, the aim was to protect the landscape from the river. The Mount Pleasant Stormwater Commission, guided by the tax and land develop-

Table 2
Factors identified and examples of how they were manifested in the analysis of the Pike River Corridor Restoration.

Elemental Type	Identified Factor	Example Manifestation in Pike River
Convening Context	Shifting Paradigms	Change in priorities of WDNR away from engineered solutions for flood control toward ecological restoration, leading to initial permit denial
	Developing a Consensus Paradigm	Agreement between WDNR and Town of Mt. Pleasant to work toward a shared concept for the Pike River
	Exploring Options and Alternatives	Wide-ranging, multi-dimensional brainstorming for how to take the concepts of the facilitation and provide enough detail to convince parties to move forward with the project.
	Iterative Design and Adaptive Learning	Shared understanding among actors of collaborative process for developing, implementing, and adapting for each of the 9 phases of the restoration program.
Management Paradigm	Stormwater conveyance	Initial watershed plans were created based on Convey/Detain/Release Paradigm.
	Basin Management	WDNR Basin Management Teams were established during the 1990′s that linked water-related offices in watersheds to provide integrated planning and decision-making. This let to initial permit denial, but also provided opportunity to support the facilitation process.
	Tax and Land Development	The initial flood control plan in 1987 was driven by the need for the Town of Mount Pleasant to remove developable land from the 100-year floodplain as a way to support a tax base for the rapidly growing Town.
	Parks and Recreation	The incorporation of a trail system in the Pike River Corridor concept plans led to a greater discussion on how to connect the ecological restoration with opportunities for recreation.
	Integrated Water Management	The development of an understanding among the participants of the interconnectedness among landuse, stormwater, wetlands and water quality and water quantity provided the language to negotiate a new plan.
Action Situation	Chapter 30 Preparation and Submittal	Chapter 30 submittal by the Town and WDNR EIS, leading to permit denial
	Facilitated Discussion and Negotiation	Six-month gathering of key stakeholders to develop a shared paradigm that reformulated the flood control plan into a corridor restoration plan.
	Project Reconceptualization and Revision	Translate concepts from the facilitation into visual designs to be part of a Chapter 30 resubmission for regulatory permit approval.
	Design and Implementation	Preparation and collaborative review of 50%, 90%, and 100% plans for each of the 9-phases of the corridor restoration
Operational Outcome	Permit Denial and Conflict	WDNR denial of initial permit application based upon the 1995 EIS, followed by legal action taken by the Town
	Approved Phased Permit	DNR acceptance of the revised Chapter 30 application which included an unprecedented 10-year time frame (subsequently extended to 20 years) for implementation of the project.
	Emergent Ecosystem Goods and Services	Benefits provided by the restoration project that were not explicitly incorporated into the structural designs for construction
Institution	Legitimacy	Recognition by parties that agreement on conceptual aspects and goals of the restoration plan would be carried forward in future designs, approvals, and implementation
	Trust	Belief in the reliability of actors in the system to work in good faith to adhere to the goals, principles and values included in the restoration plans
	Iterative Learning	Open communication and sharing of monitoring data related to performance and implementation of previous designs.
Actor	WDNR	
	MT Pleasant Stormwater District	
	MT Pleasant Town Board	
	University of Wisconsin - Milwaukee	
	Consulting Attorney	
	Engineering Consultants	
	SEWRPC	
	Wetland Consultant	
Role	Convening	WDNR Facilitation
	Sense-making	University providing the information and analysis to show that the no-action alternative was not viable
	Bridging	Town Consulting Attorney in arranging the facilitation
	Leveraging	Promotion of Integrated Watershed by seeking grants to support the additional costs for trails, wetland and prairie restoration, and land purchases
Knowledge	What is the Pike River?	Shared understanding of the past, present, and potential future for the North Branch of the Pike River
	Community Engagement	Understanding and appreciation of the value community participation could add to the restoration project through, for example volunteer work, activities, education, communications, fund-raising, political lobbying etc.

ment management paradigm, saw this project as a way to continue to grow and expand the tax base. Flooding was considered a limiting factor and the Town had issued a stormwater tax to raise funds for the project. The SEWRPC plan was being operationalized by an engineering firm who worked with the Town to apply for a Chapter 30 permit with the Wisconsin Department of Natural Resources. This paradigm is represented in the following quotes (parenthesis added to provide context).

> *"They (WDNR) don't get it. The farmer's land is their retirement savings. They've been paying extra taxes for 10 years now (since the 1987 SEWRPC Plan) so the town has the money to take their land out of the floodplain. Their kids don't want to farm. If they can't sell it to build homes because of flooding, they're stuck."* (Statement by a member of Stormwater Commission during the 1997 Facilitation)

> *"The Town had passion to make this happen. I don't know if you've ever had your home flooded. It's an ugly mess. Your life is turned upside down and (you) don't ever really recover. They needed to find a solution. People were angry, yes. But they were acting with compassion"* (Consulting engineer interviewed for the 2015 maintenance plan)

Even though the project and plan adhered to the dominant paradigm of stormwater management, from the start of the planning process (1983) to the time it came to applying for a Chapter 30 permit (1996), the WDNR had undergone a restructuring to

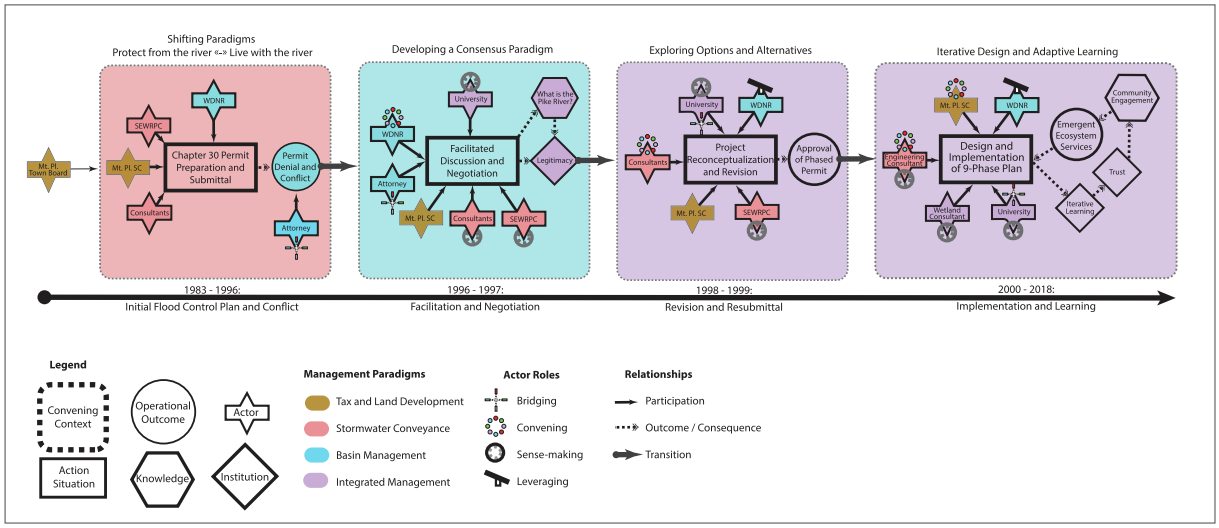

Fig. 3. Pathway to Integrated Management and Emergent Ecosystem Goods and Services in the North Pike River Corridor Developed Using a Hybrid Management and Transition Framework applied to the North Pike River Corridor Restoration.

focus on basin management. This changed perspective by the WDNR was incorporated into in their approach to and evaluation of the EIS.

> "*Even though SEWRPC considered a number of alternatives, some local residents feel that over the ensuing 10 years, attitudes and priorities may have shifted enough to warrant consideration of some other options. Others see the EIS as an opportunity to more closely examine the land use impacts of eliminating the floodplain in an urbanizing area*" *[. . .] "This 1990 inventory of the river's fishery resources offers encouragement. . . . the survey demonstrates that the Pike River is a 'system that appears to be reestablishing itself' no matter how gradually.*" (J. Schimpff, WDNR - Wisconsin Natural Resources Magazine, Volume 17, Number 4, Pages 12–16, August 1993)

This shift in management paradigm resulted in viewing these permits through a lens more heavily influenced by the Public Trust Doctrine and resulted in the denial of the initial permit application. The WDNR cited the further degradation of a navigable water as reason for permit denial and that a 'no action' alternative was feasible, leaving the Pike River to heal itself absent of anthropogenic intervention. This shift in management paradigm from protecting landscapes from storm flows, to living with dynamic river systems at the state scale resulted in the operational outcome of conflict over permit denial between the Town and the WDNR.

> "*The original attitudes within the DNR at the time we started did not give this project much opportunity or expectation of even moving forward much less succeeding. The water quality specialist who was permitting the project sent a post-it note that was on the original permit when we received it and it had a hand drawn picture of a pig with wings on it, indicating that the project would occur when pigs fly. It was a real indication that the DNR had a negative attitude towards the project*" (Consulting engineer interviewed in 2018)

The typical way to settle disputes of this nature was through the court system. However, the lawyer hired by the Town to argue their case drew from their experience as the State Intervenor and steered their client toward facilitation over litigation. To move the action situation out of the courts, the lawyer had to play the role of a bridging agent. Drawing on their relationships with both the Town and WDNR, the lawyer worked to steer the conflict toward a facilitation process where a potential negotiated agreement could be established. The bridging role was well-represented in the process of putting together the facilitation team for the Town.

> *"He (the attorney) called me one day out of the blue. He knew that I'd been involved in stream restorations with WDNR and explained to me that the Commission and engineers for Mount Pleasant needed to think and talk differently about the project. They need to use different words to describe what they want to do. They can get their flood control and make the river better at the same time*" (University researcher notes from 1997 Facilitation).

Facilitation and permit revision (1996–2000)

Negotiating a consensus management paradigm

The facilitated discussion action situation occurred between the WDNR and Town between 1996 and 1997. In this situation, the WDNR served the role of convenor, bringing the two groups together along with calling on outside groups to help inform the discussion. The law firm continued to bridge across experts, serving as facilitators to ensure conversations were fair and productive. Research scientists at the University of Wisconsin-Milwaukee were brought in to evaluate both the current ecological status of the Pike River and provide projections for different alternatives. This use of an independent actor to assess the situation, and provide objective information, helped institutionalize 'legitimacy' in the process.

Serving in the role of sense maker, the university communicated their findings. For instance, scientists gathered additional data and compared the trends in declining habitat with bank erosion due to urbanization. This relationship indicated that as long as the Town continued to develop, the Pike River was never going to recover (Town of Mount Pleasant Storm Water Drainage District, 1997).

> *"The 'no action' alternative combined with projected landuse changes will result in the progressive deterioration of this already challenged water body. Increased peak flows will accentuate an already unstable situation, leading to increased bank erosion, sediment transport downstream, and degraded aquatic habitat*" (University presentation during 1997 facilitation)

These conditions provided an opportunity for the group to generate new knowledge and redefine what the Pike River could be. There were significant hurdles to navigate. In particular, the WDNR lead attorney frequently used the phrase "*slippery slope*" and mentioned their concern over the dangers of setting precedent by allowing the Town to "*dig the river deeper and wider to create in channel detention storage*" to control flooding would be a clear violation of the Public Trust Doctrine embedded in the Wisconsin State Constitution (Wisconsin State Legislature Article IX, §1).

As the project ideas started to take form through these facilitated discussions, university and engineering firm actors both served as 'sense makers' that informed an integrated management paradigm of increasing flood control capacity while providing habitat and restoring ecosystem function. Maps of historic prairie habitat provided inspiration for a riparian restoration instead of full focus on the stream channel. The development of this new knowledge helped bolster the legitimacy of the process by establishing buy-in from all parties on the reimagined goal of the project. Noticeable changes and development of a shared language occurred during this process, reflecting a new underlying mental model for the project.

> *"Also, for obvious reasons, I would prefer that the text use the term 'stream channel restoration' types in lieu of 'channel modification' types*." (WDNR biologist memorandum, 1997)

Options and alternatives

Once an 'integrated management' paradigm was established, the engineering firm continued to convene the major players in the 'project modification' action situation. Here, options and alternatives were discussed to get buy-in from the WDNR as a new project was developed. A critical juncture came when the flood modeling engineers, prodded by the ecologists agreed to "remodel" the watershed using multiple smaller retention/detention basins spread throughout the river rather than one big basin at the downstream termination of the project. The legitimacy established in the facilitated discussion action situation allowed for the engineers to open up to novel ideas of distributed detention and designing for complex multi-stage channels. These elements of project design allowed for increased habitat diversity throughout the project while still maintaining storage capacity and mitigating flood risk. SEWRPC served a sense-maker role during this period since there was significant disagreement on the adequacy of floodplain modelling, given uncertainty on development patterns, land use projections, and rainfall patterns in the face of climate change.

The operational outcome of these discussions was a reapplication for a Chapter 30 Permit, which was modified to allow for a phased implementation approach. It also extended the timeline to 20 years for implementation to provide relief from the pressure of meeting compliance while trust and legitimacy institutionalized across groups. This need for continued engagement to maintain trust in the process was incorporated into many of the 55 special the conditions attached to the permit. Condition #53 explicitly stated that the Town appoint a person or persons to conduct ongoing daily monitoring and quality assurance for all on-going activity relevant to water quality, stream habitat, and biota, and that weekly reports be submitted to WDNR covering the prior week's activities, any problems encountered, and solutions implemented. This condition was met by contracting with the University and wetland consultant and established an expectation for weekly communication among the parties involved, that carried through across the duration of the 9 phases of construction.

The shifting of paradigms that occurred throughout the facilitation and project revisions is captured in the following excerpt from the 1997 Chapter 30 Application Environmental Analysis Compliance.

> *"The regulatory history of this project now exceeds thirteen years. During the first quarter of 1997, Wisconsin Department of Natural Resources (WDNR) staff and the Mount Pleasant Storm Water Drainage District No.1 (District) devoted very substantial monies and staff time to a facilitation process to develop an appropriate model of partnering associated with this watershed.*
> *The WDNR is in a transitional mode between its historical water regulation and zoning program and the recently announced Watershed Management Program. The latter is built upon the twin principles of a holistic-habitat approach and a partnership with the major customers in the watershed.*
> *The Pike River Project, having gone on over two decades, is caught in the inter-generational transfer. However, both the WDNR and the District believe that the Watershed Management Program methodology will provide the most economic and efficient manner for processing the project in an ecologically acceptable manner*." (WDNR Chapter 30 Review, 1997)

Implementation and learning (2001–2015)

Iterative design and adaptive learning

The modified permit broke the project into 9 phases with the Mount Pleasant Stormwater Commission convening the WDNR, contracted engineering firm, university personnel, and a wetland consultant throughout the process. As part of the development of the design for each phase, the parties would meet to go over lessons learned, discuss changes in tactics, and make any adjustments needed to the implementation plan. Because the university served multiple roles within and across phases (including habitat design, construction quality assurance, and long-term monitoring of the restoration of ecological integrity) university personnel functioned as bridging agents as staff from the Town, WDNR, and engineering firms changed throughout project implementation. Contracted experts also served as sense makers throughout implementation by interpreting the results of previous phases and making informed decisions regarding how to best proceed. University staff utilized data from monitoring construction activities, assisting with habitat feature placement, as well as tracking water quality and biological community integrity (invertebrate, fish, and vegetation).

The Town also convened weekly status report meetings with all parties involved to make adjustments to project implementation in real time. For example, instead of writing in where habitat structures would be placed, they were written in the plans as "determined on site with consultation with restoration ecologist". The deference provided to the ecologists for fine tuning features was a product of trust built into the process as contractors were initially hesitant to operate with ambiguity. Setting up the project implementation to allow for learning, thus, built trust among the parties to work together to creatively solve problems resulting in emergent ecosystem goods and services without running afoul of the permit.

> *"We saw what the solution looked like. A beautiful solution. It added fuel to the fire and pushed us to say 'let's keep it going'. As an engineer, we never get to do what they asked us to do. We seldom get to be part of creating the vision. Here we got to be creative. They (university and wetland scientist) didn't go away. They kept*

pushing us with their persistence to make it happen" (Design and construction engineer interview, 2018)

This trust also allowed for the group to allow key stakeholders and community organizations to join the process, accepting knowledge provided through community participation. The Pike River is dominated by a diversity of land uses including residential, urban, commercial/industrial, and agricultural. Bringing these stakeholders in, when appropriate, allowed for an understanding of how the Pike River could be valued, resulting in the emergent ecosystem goods and services outside of flood control and habitat restoration (see Fig. 2). For example, distributed flood storage resulted in increased habitat for waterfowl, drawing attention from governmental agencies as well as non-governmental organizations like the United States Fish and Wildlife Service and Ducks Unlimited respectively. Bolstering these goods and services, through increased stakeholder engagement, then fed back into the implementation action situation as they became attributes of the system to be managed and maintained over time. These emergent dynamics, not directly designed into the restoration plan were appeared throughout the interviews conducted for the 2015 Maintenance Plan, and are represented by dashed lines in Fig. 2.

"Historically there was not a lot of support. Residents along the corridor adamantly opposed the project. 90% of condo owners near phase 1 opposed but by the end of the project were offering to cook construction workers meals. It is now seen as an amenity." (WDNR Basin Supervisor, 2014 interview)

"Employers nearby see the Pike River as a balancing work/life opportunity. It can help in recruiting employees who want to bike to work or want to run or walk during lunch. It helps to get younger talent from the cities and places like Chicago. One local company has organized biking groups as part of its wellness program." (Interviewer notes from meeting with business leaders in 2014)

Discussion

Convening context and roles in complex decision making

Understanding the process of transformation through the convening context allowed for key roles within each action situation to become apparent. For instance, in the Shifting Paradigms convening context, the town lawyer played the role of bridging agent through convincing the Town to work with the WDNR to resolve the issue instead of taking them to court. This affirms Amsler's call to incorporate the legal context into environmental governance, as the lawyer's specific knowledge of the social and legal landscape allowed for the group to identify opportunities to bring about resolution from within the system instead of forcing decisions from above (Amsler, 2016; Wenger-Trayner and Wenger-Trayner, 2021). These aspects included experience bringing permit denial issues in front of the State Supreme Court, relationships with key personnel in the WDNR as well as an understanding of the paradigm shift going on within the organization. These findings can also be seen as affirming Baggio et al.'s (2015) experimental findings in that the behavior of key actors at the onset of a collective action problem influenced the system's trajectory. The lawyer's deep understanding of the convening context allowed them to influence the system at an important juncture and redefine the process from one of legal interpretation to one of facilitated discussion involving those who are involved in the issue (Rayner and Bonnici, 2021).

The influence of convening context on the roles actors played was apparent across all action situations. In the Negotiating a Consensus Management Paradigm convening context, the WDNR played the role of convener and shared power with the town in defining goals of the project. Through allowing the university and engineering firms to serve as sense makers and inform project development, a shared vision of the Pike River was formed that would not have materialized through dispute resolution in the court system. This supports findings that leadership is necessary in the establishment of a new management paradigm, but that it does not serve a 'command and control' role (Lichtenstein and Plowman, 2009). Instead, it is plastic, context dependent, and allows for emergence and self-organization (Faulkner et al., 2018). This institutional form of leadership, through convening, bolstered the legitimacy of the process by seeking out objective expertise and allowing those findings to inform adaptations to the project resulting in the emergence of an integrated management paradigm for the Pike River.

The Iterative and Adaptive Learning convening context highlighted how stakeholders both within and outside of the focal action situations were necessary for the multiple benefits of the project to be fully realized (Dennis and Brondizio, 2020; McGinnis, 2011). Pre-phase and weekly project status meetings, along with public forums, were seen as venues for learning and provided consistent forums of interaction between affected and affecting parties, a necessary condition in the building of trust (Lubell, 2007; Ostrom, 2009b). In this convening context, the trust and legitimacy present was built in prior action situations and created the conditions for actors with other priorities (or problem frames) to participate when appropriate, creating a rich picture of the Pike River SES (Dennis and Brondizio, 2020). Specifically, sense making from outside experts allowed residential, recreational, and commercial and industrial stakeholders to gradually take ownership of the Pike River, providing them with agency in the process which is necessary for successful transformation (Westley et al., 2013). Their participation brought about emergent ecosystem goods and services that define the Pike River Corridor (Mount Pleasant Stormwater Commission, 2015).

Another important aspect to note throughout the process was that key roles changed as the convening context moved from conflict and negotiation to project design and implementation. This was not surprising in and of itself as the MTF outlines that roles held by actors are specific to the action situation and therefore do not belong to the actor in general (Pahl-Wostl et al., 2010). However, the point of interest here is how the roles changed as the process evolved, and trust built among the key players. The initial conflict required the bridging agent to be an outsider, the town's contracted lawyer, to facilitate discussions that resolved the conflict and began the process to build legitimacy and trust. However, after legitimacy was established and the vision for the Pike River Corridor defined, the role of bridging agent could be played by those actively involved in the process of project development and implementation. This finding provides a distinction to the claim that cross sector collaboration is more likely to be successful when opposing groups have a 'linking mechanism' or common cause to build upon (Crosby and Bryson, 2010). The Town wanted to solve the flooding problem in order to continue its trajectory of suburban development. The WDNR could not allow the Town to implement the flood control project as designed due to its potential ecological impacts. What this case study shows is that when a 'linking mechanism' is not present at the outset of a collaboration process, structured, facilitated discussions can create trust and a common vision in order to move forward.

Integrating management paradigms as making space for learning

There were several paradigm shifts that occurred throughout the Pike River SES's transformation from a liability for development to a community asset. First, the WDNR's shift from 'stormwater conveyance' to 'basin management' initiated conflict through

the denial of the Town's 1996 permit application. However, this shift toward more holistic watershed planning also made the organization more open to facilitated discussions with the Town to resolve the problem, setting a new baseline for future events surrounding this issue (Michaels et al., 2006). This cross-scale interaction, first through facilitated discussion then through project redefinition and implementation, created a window of opportunity for broader participation and innovation in the project planning process (Chaffin and Gunderson, 2016). The increased institutional capacity also provided groups involved in the facilitated discussions the ability to redefine what the Pike River could be by generating new knowledge through gaining a better understanding of the state and trajectory of the system (Michaels et al., 2006).

The learning which occurred in the Negotiating a Consensus Management Paradigm convening context also resulted in the emergence of a new integrated management paradigm. Deliberation made space for actors like the university and hired engineering firms to play the role of sense maker, the WDNR and Town were able to sustain their underlying assumptions of the system and create a project that both solved the town's flooding issue while restoring habitat and fulfilling the WDNR's public trust duties (Mount Pleasant Stormwater Commission, 2015; Stirling, 2009).

This form of social learning was able to continue in the Implementation and Adaptive Learning convening context as additional groups were brought into the process, took ownership of the Pike River Corridor, and contributed to the emergence of novel ecosystem goods and services increasing overall community well-being. An example of this was the reduction of resistance through public education at open forums during the implementation of the project's early phases. Initial resistance to putting in trails as part of the project was resolved through deliberation and learning that reframed these features from threat to individual safety to providing access to a community asset (Mount Pleasant Stormwater Commission, 2015). The deliberative nature of public engagement provided a venue to collaborate with stakeholders, built trust in the process across group divides, and brought the community together through place attachment in the Pike River Corridor (see Figs. 2 and 3; Commission, 2015; Faulkner et al., 2018; Horlings, 2015). These epiphanies, where new knowledge was created which influenced the trajectory of the Pike River SES (Michaels et al., 2006), occurred throughout the phases of the project as new actors became involved (see Fig. 2) and has been well documented in the social ecological systems literature (Schultz et al., 2007).

Future of the Pike River and implementation in other contexts

Since the completion of the corridor restoration in 2017, the resilience of the system has been tested in several ways. For example, the increasing frequency of extreme rainfall events has repeatedly demonstrated the capacity of the restored corridor to mitigate flooding and maintain its structural integrity in the face of record stream flows. Although invasive plant species continue to threaten the native vegetation in the restored prairies, a network of volunteers has formed to work with wetland scientists to support management actions and embrace education initiatives. When a large corporation made known its plans to develop a massive manufacturing footprint in the watershed, individuals and organizations rallied to protect the Pike River Corridor, and lobbied politicians to push back and ensure that the restoration would be protected. As a result, the corporation agreed to fund a restoration initiative for one of the major tributaries of the North Pike River. Although any of these examples could be considered evidence of social-ecological "success", each also carries a cautionary message for being cognizant of future threats and blind-spots. The Pike River Corridor Long-term Maintenance Plan recommended the creation of Partnership Advisory Committee to provide input to assist the Village in balancing the deployment of resources and investments among the diverse needs for maintaining and growing the goods and services provided by the Pike River. The planning for the form and functions of the committee are still in progress, delayed in part to the COVID-19 pandemic.

As a case study, the Pike River was able to identify the convening contexts of, and key roles played within, action situations that resulted in the transformation of a highly degraded drainage ditch into a living riparian corridor. The WDNR has undergone multiple rearrangements in organizational structure since the initial permits were issued, resulting in more centralized decision-making and less capacity for engaging with local social-political complexity. The results of the Pike River restoration project are highly context dependent and the process which unfolded may not be possible to replicate given the current management paradigms and mental models present across the different groups. It is therefore very important when applying the findings of this study, to do so in a way that allows for (instead of forcing) change to occur and to find the appropriate balance between the organizations involved and rules and norms that govern behavior (Faulkner et al., 2018; Plowman et al., 2007; Westley et al., 2013). With that, implementing the findings of this study would require convenors to be cognizant of the overarching context with which deliberation will take place (Wenger-Trayner and Wenger-Trayner, 2021; Williams and van't Hof, 2014), allow for the specific politics of place to play out between the different actors (which may require an outside entity to play a bridging or facilitation role) (Rayner and Bonnici, 2021), and be open to objective information from experts to inform the projects trajectory (Cosens, 2013; Weber et al., 2011). Below are some thoughts managers should keep in mind when engaging in multi-stakeholder environmental management processes:

- **Be cognizant of the ecological, social, and political context**: analysis of the convening contexts in this study showed that processes at play outside of the focal action situation influenced the outcomes seen in the Pike River SES. It is important to keep in mind that projects do not exist within a vacuum and other issues at play in the relevant communities of practice inform the actions and mental models of actors engaged in collaboration (McGinnis, 2011). This requires managers to have a deeper understanding of adjacent action situations, and work to lower transaction costs to bring the proper groups of people together to solve problems at the appropriate scale (Dennis and Brondizio, 2020). It may also require consultation with legal counsel to ensure that operational outcomes, as well as the collaborative process itself, are implementable (Amsler, 2016).
- **Organizational diversity is important but be sure to get the right people involved**: the transformation which occurred in the Pike River SES would not have been fully realized had it not been for the individuals involved. Although these actors represented a diversity of organizations, it was their individual buy-in to the process that allowed for the integrated water management paradigm to emerge. Much like other case studies examining collective natural resource management problems in SESs (Acheson, 1997; Olsson et al., 2007), it is important to note that 'leadership' was assigned to different roles and individuals given the context. In the Pike River SES, key individuals served bridging, convening, sense-making, and leveraging roles, many of which have been identified as forms of leadership in the literature (Evans et al., 2015), to keep the project moving forward. When approaching a collaborative, multi-stakeholder process, it is important that managers look for these traits in the participants and allow space for them to serve in these capacities.

- **Trust is required for emergence**: Work on trust has emphasized the importance of initial conditions (Baggio et al., 2015), repeated interaction (Ostrom, 2009b), and institutional distance (Lubell, 2007) when diverse groups of people are attempting to solve collective action problems. In this sense, the current study serves as an excellent confirmatory case, where the Town's trust in their attorney brought them to the negotiating table with the WDNR and repeated interaction reduced the institutional distance between the two organizations as they developed working relationships based on common knowledge. This trust amongst participants provided legitimacy of process, allowing the capacity for outside groups to influence the project during the Design and Implementation of 9 Phase Plan action situation while maintaining its core principles of habitat restoration and flood conveyance. What managers can learn from this is that trust is a prerequisite for emergence. Too often are collaborative efforts stymied because insufficient work was done either on the front end establishing trusted relationships among key stakeholders or lost due to lack of continued investment in relationship building (Mollinga, 2010; National Research Council, 1996). This may require effort throughout the collaboration process to illicit and foster shared values and management paradigms across affected and affecting parties.

Conclusions

Over the course of 29 years, the Pike River SES transformed from an agricultural drainage ditch posing a flood hazard for future development to a center piece of the surrounding community. Viewing this process through the lens of the MTF helped identify institutional factors that contributed to the transition from competing stormwater and basin management paradigms to one of integrated management focused on learning and adaptation. The addition of analyzing the convening context of each action situation allowed for key roles (convenor, sense maker, and bridging agent) to become apparent. Given the initial conflict over permit denial, it took outside actors to provide bridging functions across the Village and WDNR and build legitimacy through providing an objective assessment of the state of the ecosystem. Over time, actors changed roles as they self-organized around an integrated management paradigm that sought to define what the Pike River could be and were provided the opportunity to create it through the issuance of a flexible, 20-year Chapter 30 permit. This process allowed for the emergence of ecosystem goods and services not initially planned and were defined by the surrounding community. With recent focus in the literature on remediation, restoration, and revitalization (Williams and Hoffman, 2020), the Pike River can serve as an excellent case study to understand how restoration can transform ecosystems and the communities who take ownership of them.

However, there are things that managers must consider when seeking to implement lessons learned from the Pike River. Analyzing the convening contexts of different action situations showed that it was not just organizational representation that mattered when conflict occurred, but the specific roles played by key individuals in steering the issue to facilitation, building legitimacy and trust in the process, and allowing the community to take ownership of the project. Identifying those that need to be involved in the process is one thing but providing the space for those individuals to define their role in a collaborative learning process requires a 'leader' to facilitate, instead of drive, the process. With the looming impacts of climate change starting to take shape, managers are attempting to instill collaborative processes in natural resources management should take note of the role's actors assign themselves during group discussions. More research is necessary to understand how management paradigms can be integrated in these types of settings.

Additionally, management paradigms change over time and institutionalization occurs during windows of opportunity. After the issuance of the Chapter 30 permit, but before the end of the Pike River Project's implementation, the WNDR's basin management paradigm regarding water resources shifted toward regulatory certainty and tax and land development. The legitimacy and trust in the process built through the Facilitation and Permit Revision as well as the Implementation and Adaptive Learning eras allowed the project to continue as planned despite changes in underlying assumptions at the State scale. The resilience of the Pike River process was first established during the facilitated discussions, when major parties were open to building new knowledge together. This may not be possible given the current management paradigm of the WDNR, and restoration projects being implemented in the State of Wisconsin will most likely not have the flexibility provided to the stakeholders for the Pike River project. Instead, managers will have to develop and manage their projects with emergence in mind.

More broadly, managers interested in adopting a systems-change approach must be aware of the fluidity and ephemeral nature of the political contexts within which social-ecological systems operate. Having a sensitivity to and awareness of opportunities for engaging conflict transformation is essential. In the case of the Pike River, the trust that developed from the facilitation set the foundation for relationships that carried forward. These relationships promoted equitable voice among actors, which in turn allowed for emergence to take place.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Acheson, J.M., 1997. The politics of managing the maine lobster industry: 1860 to the present. Hum. Ecol. 25, 3–27. https://doi.org/10.1023/A:1021979718461.

Amsler, L.B., 2016. Collaborative governance: integrating management, politics, and law. Public Adm. Rev. 76, 700–711. https://doi.org/10.1111/puar.12605.700.

Baggio, J.A., Rollins, N.D., Pérez, I., Janssen, M.A., 2015. Irrigation experiments in the lab: trust, environmental variability, and collective action. Ecol. Soc. 20.

Berardo, R., Scholz, J.T., 2010. Systemic risk and network formation in social-ecological systems. Am. J. Pol. Sci. 54, 632–649.
Chaffin, B.C., Gunderson, L.H., 2016. Emergence, institutionalization and renewal: rhythms of adaptive governance in complex social-ecological systems. J. Environ. Manage. 165, 81–87. https://doi.org/10.1016/j.jenvman.2015.09.003.
Chapin, F.S.I., Kofinas, G.P., Folke, C., 2009. Principles of Ecosystem Stewardship, in: Principles of Ecosystem Stewardship. Springer.
Cole, D.H., Epstein, G., McGinnis, M.D., 2019. The Utility of Combining the IAD and SES Frameworks. Int. J. Commons 13, 244. https://doi.org/10.18352/ijc.864.
Cosens, B.A., 2013. Legitimacy, adaptation, and resilience in ecosystem management. Ecol. Soc. 18. https://doi.org/10.5751/ES-05093-180103.
Crosby, B.C., Bryson, J.M., 2010. Integrative leadership and the creation and maintenance of cross-sector collaborations. Leadersh. Q. 21, 211–230. https://doi.org/10.1016/j.leaqua.2010.01.003.
Dennis, E.M., Brondizio, E., 2020. Problem framing influences linkages among networks of collective action situations for water provision, wastewater, and water conservation in a Metropolitan region. Int. J. Commons 14 (1), 313. https://doi.org/10.5334/ijc.974.
Evans, L.S., Hicks, C.C., Cohen, P.J., Case, P., Prideaux, M., Mills, D.J., 2015. Understanding leadership in the environmental sciences. Ecol. Soc. 20. https://doi.org/10.5751/ES-07268-200150.
Faulkner, L., Brown, K., Quinn, T., 2018. Analyzing community resilience as an emergent property of dynamic social- ecological systems. Ecol. Soc. 23.
Fischer, A.P., Vance-Borland, K., Jasny, L., Grimm, K.E., Charnley, S., 2016. A network approach to assessing social capacity for landscape planning: the case of fire-prone forests in Oregon, USA. Landsc. Urban Plan. 147, 18–27. https://doi.org/10.1016/j.landurbplan.2015.10.006.
Galaz, V., Olsson, P., Hahn, T., Folke, C., Svedin, U., 2008. The Problem of Fit among Biophysical Systems, Environmental and Resource Regimes, and Broader Governance Systems: Insights and Emerging Challenges, Institutions and Environmental Change. MIT Press. doi:10.7551/mitpress/9780262240574.003.0005.
George, A., Bennet, A., 2005. Case Studies and Theory Development in the Social Sciences. MIT Press, Cambridge.
Green, O.O., Garmestani, A.S., Allen, C.R., Gunderson, L.H., Ruhl, J.B., Arnold, C.A., Graham, N.AJ., Cosens, B., Angeler, D.G., Chaffin, B.C., Holling, C.S., 2015. Barriers and bridges to the integration of social–ecological resilience and law. Front. Ecol. Environ. 13, 332–337. https://doi.org/10.1890/140294.
Halbe, J., Pahl-Wostl, C., Sendzimir, J., Adamowski, J., 2013. Towards adaptive and integrated management paradigms to meet the challenges of water governance. Water Sci. Technol. 67, 2651–2660. https://doi.org/10.2166/wst.2013.146.
Henry, A.D., 2020. Meeting the challenge of learning for sustainability through policy networks. Hum. Ecol. Rev. 26, 171–193. https://doi.org/10.22459/HER.26.02.2020.08.
Horlings, L.G., 2015. The inner dimension of sustainability: personal and cultural values. Curr. Opin. Environ. Sustain. 14, 163–169. https://doi.org/10.1016/j.cosust.2015.06.006.
Karr, J.R., 1999. Defining and measuring river health. Freshw. Biol. 41, 221–234. https://doi.org/10.1046/j.1365-2427.1999.00427.x.
Lemos, M.C., Agrawal, A., 2006. Environmental Governance. Annu. Rev. Environ. Resour. 31 (1), 297–325. https://doi.org/10.1146/annurev.energy.31.042605.135621.
Lerner, A.M., Eakin, H.C., Tellman, E., Chrissie, J., 2018. Governing the gaps in water governance and land-use planning in a megacity: the example of hydrological risk in Mexico City. Cities 83, 61–70.
Lichtenstein, B.B., Plowman, D.A., 2009. The leadership of emergence: a complex systems leadership theory of emergence at successive organizational levels. Leadersh. Q. 20, 617–630. https://doi.org/10.1016/j.leaqua.2009.04.006.
Lubell, M., 2007. Familiarity breeds trust: collective action in a policy domain. J. Polit. 69, 237–250. https://doi.org/10.1111/j.1468-2508.2007.00507.x.
McGinnis, M.D., 2011. Networks of adjacent action situations in polycentric governance. Policy Stud. J. 39, 51–78. https://doi.org/10.1111/j.1541-0072.2010.00396.x.
McGuire, S.A., Ehlinger, T.J., 2018. Analysis of social-ecological dynamics driving conflict in linked surface-groundwater systems. Ecol. Soc. 23. https://doi.org/10.5751/ES-10510-230419.
Michaels, S., Goucher, N.P., McCarthy, D., 2006. Policy windows, policy change, and organizational learning: watersheds in the evolution of watershed management. Environ. Manage. 38, 983–992. https://doi.org/10.1007/s00267-005-0269-0.
Mollinga, P.P., 2010. Boundary work and the complexity of natural resources management. Crop Sci. 50, S-1–S-9. https://doi.org/10.2135/cropsci2009.10.0570.
Moreno, J., Palomo, I., Escalera, J., Martín-López, B., Montes, C., 2014. Incorporating ecosystem services into ecosystem-based management to deal with complexity: a participative mental model approach. Landsc. Ecol. 29, 1407–1421. https://doi.org/10.1007/s10980-014-0053-8.
Mount Pleasant Stormwater Commission, C., 2015. Pike River Corridor Maintenance Plan. Mount Pleasant, WI.
National Research Council, C., 1996. Understanding Risk: Informing Decisions in a Democratic Society. National Academies Press.
Olsson, P., Folke, C., Galaz, V., Hahn, T., Schultz, L., 2007. Enhancing the fit through adaptive co-management: Creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve, Sweden. Ecol. Soc. 12. doi:28.
Olsson, P., Folke, C., Hahn, T., 2004. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. Ecol. Soc. 9. https://doi.org/10.5751/ES-00683-090402.
Ostrom, E., 2009a. A general framework for analyzing sustainability of social-ecological systems. Science 325, 419–422. https://doi.org/10.1126/science:1172133.
Ostrom, E., 2009. Building Trust to Solve Commons Dilemmas: Taking Small Steps to Test an Evolving Theory of Collective Action 207–228. doi:10.1007/978-3-540-85436-4_13.
Pahl-wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., Taillieu, T., 2007. Social learning and water resources management. Ecol. Soc. 12.
Pahl-Wostl, C., Holtz, G., Kastens, B., Knieper, C., 2010. Analyzing complex water governance regimes: The Management and Transition Framework. Environ. Sci. Policy 13, 571–581. https://doi.org/10.1016/j.envsci.2010.08.006.
Plowman, D.A., Solansky, S., Beck, T.E., 2007. The role of leadership in emergent, self- organization. Leadersh. Q. 18, 341–356. https://doi.org/10.1016/j.leaqua.2007.04.004.
Rayner, C., Bonnici, F., 2021. The Systems Work of Social Change: How to Harness Connection, Context, and Power to Cultivate Deep and Enduring Change. Oxford University Press, New York.
Reed, M.G., Bruyneel, S., 2010. Rescaling environmental governance, rethinking the state: a three-dimensional review. Prog. Hum. Geogr. 34, 646–653. https://doi.org/10.1177/0309132509354836.
Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014.
Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. J. Environ. Manage. 90, 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001.
Rockström, J., Falkenmark, M., Folke, C., Lannerstad, M., Barron, J., Enfors, E., Gordon, L., Heinke, J., Hoff, H., Pahl-Wostl, C., 2014. Water Resilience for Human Prosperity. Cambridge University Press.
Schimpff, J., 1993. Can urban streams work and play? Wisconsin Nat. Resour. Mag. 17, 12–16.
Schultz, L., Folke, C., Olsson, P., 2007. Enhancing ecosystem management through social-ecological inventories: lessons from Kristianstads Vattenrike, Sweden. Environ. Conserv. 34 (2), 140–152. https://doi.org/10.1017/S0376892907003876.
Sendzimir, J., Magnuszewski, P., Flachner, Z., Balogh, P., Molnar, G., Sarvari, A., Nagy, Z., 2008. Assessing the resilience of a river management regime: Informal learning in a shadow network in the Tisza River Basin. Ecol. Soc. 13. doi:11.
SEWRPC, 1983. A Comprehensive Plan for the Pike River Watershed. Peawuakee, WI.
Stewart, J., Tyler, M.E., 2019. Bridging organizations and strategic bridging functions in environmental governance and management. Int. J. Water Resour. Dev. 35 (1), 71–94. https://doi.org/10.1080/07900627.2017.1389697.
Stirling, A., 2009. Participation, precaution, and reflexive governance for sustainable development. In: Adger, W.N., Jordan, A. (Eds.), Governing Sustainability. Cambridge University Press, Cambridge, pp. 193–225.
Town of Mount Pleasant Storm Water Drainage District, D., 1997. Pike River Improvements: Chapter 30 Re-Submittal. Mount Pleasant, WI. doi:10.13140/RG.2.2.24747.98087.
Tress, B., Tress, G., Fry, G., 2005. Defining concepts and the process of knowledge production in integrative research. In: From Landscape Research to Landscape Planning: Aspects of Integration, Education and Application, pp. 13–26.
Walker, B.H., 2012. Resilience Practice : Building Capacity to Absorb Disturbance and Maintain Function. Island Press.
Weber, E.P., Memon, A., Painter, B., 2011. Science, society, and water resources in New Zealand: recognizing and overcoming a societal impasse. Environ. Policy Plan. J. 13 (1), 49–69.
Wenger-Trayner, E., Wenger-Trayner, B., 2021. Systems Convening: A crucial form of leadership for the 21st century. Social Learning Lab, Sesimbra, Protugal.
Westley, F.R., Tjornbo, O., Schultz, L., Olsson, P., Folke, C., Crona, B., 2013. A Theory of transformative agency in linked social-ecological systems. Ecol. Soc. 18.
Williams, B., van 't Hof, S., 2014. Wicked Solutions: a systems approach to complex problems. Self published. ISBN 978-0-473-28735-1. Accessed 14-February-2022 from http://www.bobwilliams.co.nz/ewExternalFiles/Wicked.pdf.
Williams, K.C., 2015. Building bridges in the Great Lakes: How objects and organization facilitate collaboration across boundaries. J. Great Lakes Res. 41, 180–187. https://doi.org/10.1016/j.jglr.2014.10.004.
Williams, K.C., Hoffman, J.C., 2020. Remediation to restoration to revitalization: engaging communities to support ecosystem-based management and improve human wellbeing at clean-up sites. Ecosyst. Manag. Ecosyst. Serv. Aquat. Biodivers. 543–559. https://doi.org/10.1007/978-3-030-45843-0_27.
Wilson-Grau, R., Britt, H., 2012. Outcome harvesting. Ford Found. 2012, 25.
Wisconsin Department of Natural Resources, S. of, 1995. Environmental Impact Statement for the Stream Channel Modifications of the Pike River System. Madison, WI.
Wisconsin State Legislature, 2010. Chapter NR 102, Wisconsin State Statues. United States. https://docs.legis.wisconsin.gov/2011/related/wiscon/_19.