Community-powered urban stream restoration: A vision for sustainable and resilient urban ecosystems

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Abstract: Urban streams can provide amenities to people living in cities, but those benefits are reduced when streams become degraded, potentially even causing harm (disease, toxic compounds, etc.). Governments and institutions invest resources to improve the values and services provided by urban streams; however, the conception, development, and implementation of such projects may not include meaningful involvement of community members and other stakeholders. Consequently, project objectives may be misaligned with community desires and needs, and projects may fail to achieve their goals. In February 2020, the 5th Symposium on Urbanization and Stream Ecology, an interdisciplinary meeting held every 3 to 5 y, met in Austin, Texas, USA, to explore new

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approaches to urban stream projects, including ways to maximize the full range of potential benefits by better integrating community members into project identification and decision making. The symposium included in-depth discussion about 4 nearby field case studies, participation of multidisciplinary urban stream experts from 5 continents, and input from the Austin community. Institutional barriers to community inclusion were identified and analyzed using real-world examples, both from the case studies and from the literature, which clarified disparities in power, equity, and values. Outcomes of the symposium have been aggregated into a vision that challenges the present institutional approach to urban stream management and a set of strategies to systematically address these barriers to improve restoration solutions. Integrating community members and other stakeholders throughout the urban restoration process, and a transparent decision-making process to resolve divergent objectives, can help identify appropriate goals for realizing both the ecological and social benefits of stream restoration.
Key words: urban streams, restoration, community, transdisciplinary, sustainable, co-creation, socioecological, ecosystem service, multi-benefit

The last 2 decades have seen dramatic shifts in societal attitudes towards urban stream corridors (Roy et al. 2008, Hale 2016, Parr et al. 2016, Hobbie and Grimm 2020). Urban streams, which are often channelized and buried as part of engineered solutions to stormwater conveyance and wastewater disposal problems (Delleur 2003, Elmore and Kaushal 2008), are increasingly recognized as ecological and social amenities worthy of restoration and public investment (Palmer et al. 2014, Hong and Chang 2020). Cities are looking for opportunities to restore streams to meet multiple objectives, including regulatory compliance, flood relief, aesthetic improvements, and recreation (Doyle and Shields 2012, Naiman 2013, Baker et al. 2014, Hawley 2022). It is estimated conservatively that federal programs in the United States fund ecological restoration at a rate of ~$1.9 B/y (BenDor et al. 2015), of which ≥$1 B/y goes into stream restoration (Bernhardt et al. 2005).

Restoration is a complex social process, driven by legal and regulatory requirements, economics, the values and goals of diverse stakeholders, and broader cultural perspectives on nature (Baker et al. 2014, Smith et al. 2014, Lave 2016, Nost et al. 2019). Despite the inextricable relationships between social and ecological dimensions of urban streams, most of the stream restoration literature has focused almost exclusively on technical issues and approaches (e.g., Walsh et al. 2015, Lammers et al. 2020). Although these are important considerations, even the identification of problems is ultimately a product of social values. Thus, explicitly incorporating social dimensions into restoration is essential for adequately defining and achieving the goals and objectives of the restoration itself (Smith et al. 2016).

Practitioners may not recognize the social dimensions of a restoration project, nor their influence on project location, objectives, and design (Baker et al. 2014, Nost et al. 2019). For example, systematic biases may lead restoration projects to be unjustly distributed, with more restoration occurring in areas with highly educated, wealthy, and non-Hispanic white populations (Stanford et al. 2018). The full range of stakeholders, including community members, may not be considered in stream restoration, and even if they are, their perspectives may not be well integrated into project development (e.g., Wohl et al. 2015).

Only in the past decade has the freshwater science literature started to acknowledge the social dimensions of urban stream restoration (Smith et al. 2014, 2016). One focus has been on assessing the social benefits of completed restoration projects (Roy et al. 2008, Usher et al. 2021). Other studies have explored the effects of incorporating social dimensions in the earlier stages of restoration identification and design, showing evidence that residents value being involved in stream restoration early in the process (e.g., Deffner and Haase 2018, Hong et al. 2018, Bell et al. 2020, Basak et al. 2021). However, differences in goals and agendas among various stakeholders can be a major challenge in developing plans for stream restoration (i.e., goals can span improving flood management, ecological habitat, aesthetics, recreation, community building, etc.; Smith et al. 2014, Moran et al. 2019). Despite the challenge in aligning restoration goals, public involvement in the design of restoration projects can increase support for restoration projects (Metcalf et al. 2015) and can have important social justice benefits by improving restoration outcomes, elevating new voices, and recognizing community power (Moran et al. 2019).

Communities can become more deeply engaged in stream restoration processes than they typically have been when more participatory approaches to restoration planning are adopted (for examples see Moran et al. 2019, Usher et al. 2021). Although the public may appreciate a restored stream that only meets the professionals' visions (e.g., Deffner and Haase 2018, Hong et al. 2018, Bell et al. 2020), when given the opportunity, the public may also bring a diversity of alternative visions for restoration to potential project areas. For example, Usher et al. (2021) described a tremendous range of visions brought by community members during a restoration-visioning process, which included trails, community gardens, outdoor learning spaces, a treehouse, wetlands and woodlands, ponds, play areas, and much more. Creating participatory processes that engage communities may yield more successful, co-designed stream restoration projects, where

widespread community support can help shift watershed-wide practices to better maintain and further improve the restored system (Moran et al. 2019).

This paper represents a synthesis of the discussions and outcomes from the 5th Symposium on Urbanization and Stream Ecology (SUSE5; 12–15 February 2020), an interdisciplinary meeting held every 3 to 5 y, most recently in Austin, Texas, USA. We have drawn on the common threads that emerged from discussions around 4 local case studies at SUSE5 as well as from the academic literature, technical advice, and our own professional experiences to develop a vision for more successful restoration of urban stream systems. We begin with an overview of the SUSE5 meeting with a focus on the case studies and team makeup. We describe the key barriers to improved community involvement in urban stream restoration, particularly as emphasized through examples from SUSE5. Then, we offer a vision for a transdisciplinary, integrative, and inclusive community powered approach to urban stream management. This paper envisions restoration projects that acknowledge the local social–ecological context in which restoration projects are identified, designed, and implemented and will lead to equitable provision of ecosystem services across the diverse social landscapes typical of cities. Finally, we offer some strategies for addressing barriers to community involvement in restoration through actions inspired by the community-powered vision. We emphasize that this paper is not a lessons-learned or how-to guide to community-based stream restoration. Instead, our intent is to build awareness of the sociopolitical complexity of stream restoration among urban stream ecologists and to start a discussion as a community of practitioners, regulators, and funders to explore the potential roles of community stakeholders in achieving successful and sustainable urban stream restoration.

THE SUSE5 MEETING

SUSE5 offered an opportunity for professionals (spanning the environmental, social, and political sciences) and practitioners (of stream restoration and management, nonprofit community groups, and local citizens) to share their research, experiences, and social values in the context of 4 local case studies of urban stream restoration. The meeting used a structured decision-making framework (Gregory et al. 2012) to facilitate collaboration in addressing "wicked problems" (pp. 160–161), a term applied to complex social policy and planning problems that are inherently unsolvable because of their interconnected nature, evolving conditions, and often competing goals (among other factors; Rittel and Webber 1973).

From an inventory of streams draining through Austin compiled by City of Austin (COA) staff, we identified 4 case-study sites (SUSE5 2020, Part 2; Fig. 1). Selected sites had documented problems that were not already under planning and design phases within the COA's project-development structure. These sites were representative of the dominant stream problems (i.e., flooding and erosion) found in Austin as determined by a combination of citizen complaints and COA field-identified projects. The selected sites also included other common urban stream stressors (e.g., degraded habitat, poor water quality, altered flow regimes) and a range of social equity issues that commonly go hand-in-hand with degraded urban streams, both in Austin and urban areas globally (e.g., Booth et al. 2016, Gupta and Verma 2017, Pulford et al. 2017, Chakraborti and Shimshack 2022), including legacies of racism and under-investment in historically disadvantaged communities. These equity issues commonly coincide with chronic flooding problems and other socioeconomic impacts at these sites. The lack of obvious stormwater management solutions made these 4 case studies complex and challenging problems.

During the February 2020 meeting, each case study was assigned to 3 teams of 10 to 12 SUSE5 participants (n = 12 teams). Teams were intentionally structured into 3 categories (4 teams in each category): 1) participants within a single discipline, comprising only biologists or only engineers; 2) participants from multiple disciplines, comprising biologists, engineers, and planners; or 3) participants covering transdisciplines, comprising a mix of professional backgrounds plus members of the local community (Bixler et al. 2022). Each of the 4 transdisciplinary teams included 3 community members. Each of the 12 teams included 1 or more COA employee to provide local and historical perspectives of the case study and to gather potential solutions from team discussions to inform the next stage of the COA's project-development process. The biologists, engineers, and planners represented a mix of academic, professional, and practitioner backgrounds, along with students and government agencies originating beyond the COA. In sum, there were >150 attendees from 6 countries and ~20 US states, with ~15% of attendees being staff of the COA.

Over the 3.5-d meeting, teams met in work sessions scoping the problem(s) associated with their field site, identified project objectives and values, visited their respective site, and refined alternative solutions. At the end of the meeting, each team presented highlights from their work sessions, including problem statements and proposed conceptual solutions for their case study. In most instances, solutions involved tradeoffs among the various stakeholder interests and perspectives. Although the initial focus of the meeting was not on finding socially equitable solutions to stormwater management concerns, a primary outcome from the general discussion was recognition that such issues, whether acknowledged or not, underlie many eco-sociological tradeoffs in urban stream management.

Implicit in this workshop was a goal of identifying barriers to community involvement. Although only $^1/_3$ of the teams included community members, all teams had diverse values and expertise that, ideally, should be cooperatively incorporated into local stream restoration solutions. However, barriers to such inclusion were a common theme that emerged

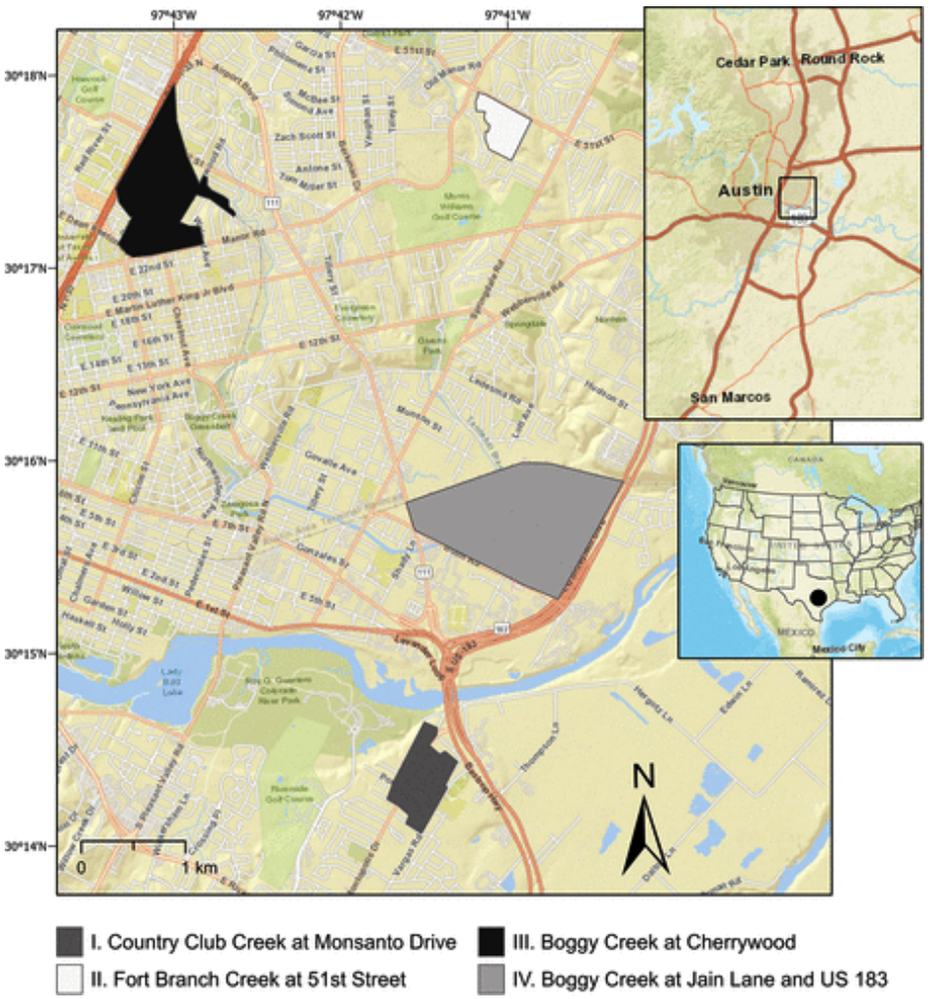

Figure 1. Map of 4 case study sites (grayscale polygons shaded from black to white) from the 5th Symposium on Urbanization and Stream Ecology, an interdisciplinary meeting held every 3 to 5 y in Austin, Texas, USA. All sites were located just north and east of downtown Austin. See the online edition for a color version of this image.

during the meeting. This exercise highlighted both the importance of community involvement in developing inclusive and socially sustainable solutions, and some of the common barriers that nonetheless can impede community involvement. Community representative and water policy expert Carrie Thompson reflects on the SUSE5 meeting:

> "I was assigned to a watershed that I was not familiar with in Austin. My group was a mix of experts and a few local community members. We were very dependent on the local community resident representative and Austin staff to orient us to the site and larger issues."

BARRIERS TO IMPROVED COMMUNITY INVOLVEMENT

Team discussions and problem solving at SUSE5 revealed multiple barriers to implementing a transdisciplinary, community-powered approach to urban stream restoration. We organize these barriers into 4 categories: 1) regulatory requirements and governance structures, 2) limited resource availability and allocation, 3) trust and power differentials, and 4) differences in problem definition and what constitutes success (Table 1, Fig. 2A–D). These barriers are interconnected, although they influence development of restoration projects and management solutions differently and at different spatial scales. Below, we describe the barriers in each of these categories based on discussions that arose during the SUSE5 meeting. We also note that there are many other instances in environmental restoration to which these barriers may also apply (Table S1), and so these findings are likely more broadly relevant beyond the improvement of urban streams.

Regulatory requirements and governance structures

Regulatory and governance structures that guide stream restoration decisions may impede meaningful community

Table 1. Case study sites from the 5th Symposium on Urbanization and Stream Ecology (SUSE5), an interdisciplinary meeting held every 3 to 5 y in Austin, Texas, USA, and the barriers to better community involvement identified by SUSE5 participants (see Fig. 1 for site locations, Fig. 2A–D for barriers). – indicates that team deliverables and notes did not explicitly discuss that type of barrier for a given case study. For more information about the study sites and concerns identified by the City of Austin, see SUSE5 (2020). USACE = United States Army Corps of Engineers.

		Barriers to community involvement			
Site name	City of Austin concerns	Regulatory requirements and governance structures	Resource availability and allocation	Trust and power differentials	Conceptual differences
Boggy Creek at Cherrywood	Flooding, erosion, water quality	Conflicting municipal drivers	Limited space/parcels for green-infrastructure stormwater solutions	–	Scope mismatch between proposed solutions and watershed-scale drivers
Boggy Creek at Jain Lane	Aging or damaged flood-control infrastructure, erosion	Requirements from government agency remote from community	–	Legacies of institutional racism, large channelization project by USACE	Community access barriers due to USACE project, rail lines
Fort Branch Creek at 51st Street	Flooding, erosion, water quality	Multidimensional solutions require cooperation among city departments that may not coordinate well	Limited space upstream for more comprehensive channel restoration	–	Disagreement about scale (watershed vs reach)
Country Club East Creek headwaters at Monsanto Drive	Flooding	Single-solution mindset focused on flooding	Upgrading drainage infrastructure is very costly	Historic disinvestment in the neighborhood creates mistrust, concerns about green gentrification	Headwater or buried stream, no context for public, no focus for restoration

involvement. For example, in highly regulated and controlled rivers, engineers may focus on building and operating dams and levees to provide flood protection and insurance companies may sell insurance for flood damage, but there may be no consideration of residents' concerns about living in floodplains other than those related to flooding (Pahl-Wostl 2006). Moreover, agencies that administer or interact with stream restoration projects may have narrow objectives or circumscribed missions. For example, projects may be limited to environmental, safety, or property protection goals while ignoring issues of equity and justice, community identity and well-being, or other social outcomes (even though many agencies explicitly mandate public comment or participation and facilitate partnerships with stakeholders; USEPA 2008, Larson and Lach 2010).

Two examples from SUSE5 display this primacy of regulations or institutions over broader community needs. The identified need for the Boggy Creek at Jain Lane project was driven by the United States Army Corps of Engineers' regulatory requirements for flood safety and geomorphic stability (Table 1). Discussion of potential community interests and objectives was outside of this regulatory scope. At the Fort Branch Creek at 51st Street, SUSE5 participants recognized that narrow objectives and missions, which were limited to flooding, erosion, and water quality, were a barrier to community involvement (Table 1). In contrast, community members identified broader objectives of social equity. Here, SUSE5 participants recognized that multifunctional and equitable solutions (i.e., those that include both social and ecological objectives) might require coordination of funds and integration of goals among agencies with separate, nonoverlapping scopes and missions. Without clear protocols or precedent, COA staff named this coordination among agencies as a possible barrier to multifunctional solutions.

The structure of the bureaucratic processes (e.g., short turnaround times between proposing and completing a project) and requirements for project contracting (e.g., permit applications, budget restrictions) can exclude proposals championed by community groups that do not have prior restoration contracting experience (Taylor and de Loë 2012). Project proposals from professionals who are already familiar with the competitive process for contracting typically have an advantage over the recommendations of residents (Anguelovski et al. 2019). Further, requirements to consider

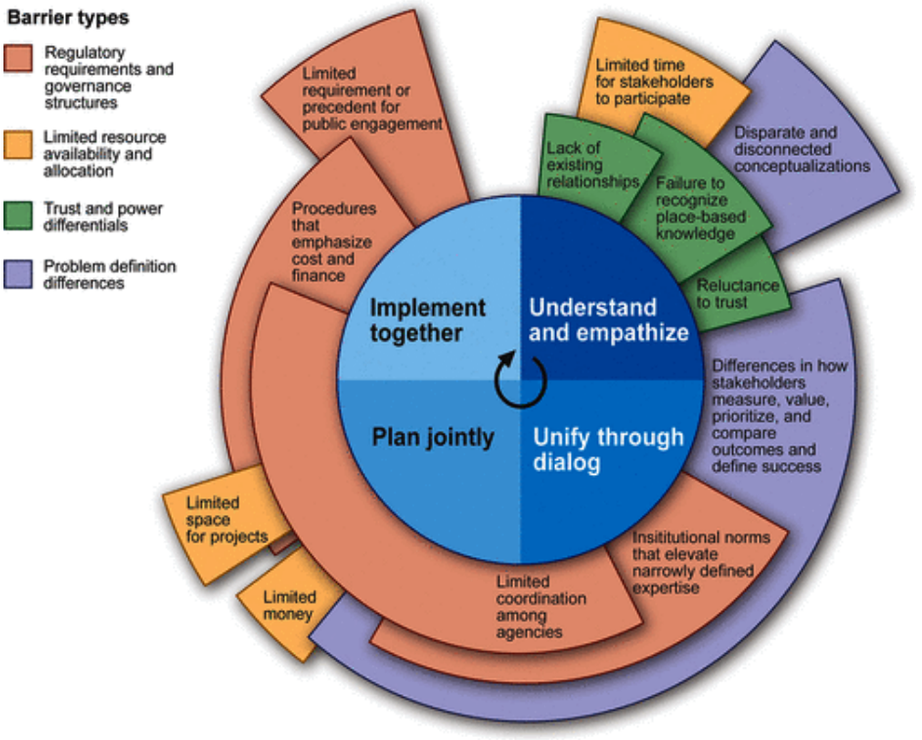

Figure 2. The actions envisioned in this paper (center circle) may help overcome barriers to meaningful community involvement. Actions occur in clockwise order, from understand and empathize (A), unify through dialog (B), plan jointly (C), and implement together (D). By beginning the process with understanding and empathy, stream restoration projects may overcome barriers involving trust and power differentials, creating trusting relationships that endure and facilitate subsequent actions. Other barriers, like distribution of funding to promote community involvement, may be overcome through deliberate institutional commitment to plan jointly with communities on how and where limited funds are spent. See Table 2 for related actions that can be taken to overcome these barriers. See the online edition for a color version of this image.

cost–benefit analyses may preclude incorporation of multidimensional goals, particularly where nonfinancial costs and benefits are difficult to quantify. In addition to these constraints, common (and typically the only) practices used by governments for soliciting community stakeholder knowledge and engagement (e.g., town hall meetings) may be ill-suited to identify or achieve multiple goals (Moran et al. 2019). Finally, although hiring a hyperlocal workforce may provide direct economic benefit to the local community (as was proposed by the transdisciplinary group in the Fort Branch Creek at 51st Street case study), procurement rules, such as liability insurance and trade certifications, may create barriers to hiring a local workforce for project implementation. Eric Paulus reflects on the SUSE5 meeting:

> "As a community member and leader of a grassroots environmental organization trying to advocate for watershed improvements, I not only don't see any way to have a seat at the table, but I don't even know what room or even building the table is at. I have no doubt this is by design and the impetus is on city departments to change this if they are serious about equity and inclusion."

Limited resource availability and allocation

Availability, access, and allocation of resources, such as time, money, and space, can generate barriers to equitable and representative involvement of the community in stream restoration. Funds for stream restoration projects may be allocated to achieve a specific objective (e.g., habitat restoration, flood control, health hazards) that limits engagement to those with single-objective professional expertise. Although professional expertise is valuable, setting specific objectives too early in the process may limit opportunities to involve community members with place-based knowledge and a broader perspective of social needs who may provide unique perspectives and additional objectives (Anguelovski et al. 2020). Limited funding can further constrain the scope of a project and reduce participation by community groups. For example, lack of financial compensation for community participation in the planning process may exclude potential stakeholders who are unable to undertake unpaid work (Travaline et al. 2015). Similarly, community members (especially in underserved neighborhoods) who are voluntary participants may not have the time, availability, or capacity to attend planning meetings or participate in other

meaningful ways (Larson and Lach 2010, Travaline et al. 2015). Meaningful community engagement is time consuming (Travaline et al. 2015), and compressed project timelines that encourage a streamlined process may preclude broad participation for the sake of simplicity and speed.

Space in which to implement projects can be a constraint, particularly in older, densely developed neighborhoods or highly urbanized settings. The acreage needed to implement stream restoration projects, and green-and-blue infrastructure more broadly, may be at a premium in cities (Kenney et al. 2012). In the Boggy at Cherrywood case study, participants identified stream restoration solutions that would provide accessible, appealing greenspaces as severely limited by available space (Table 1). Yet even the parcels acquired and used for stream restoration projects to meet multifaceted ecological and community needs may be chosen for their convenience, availability, and cost rather than their ideal locations (Moran 2007), which can further discourage participation (or engender outright hostility) by community members.

Across all case studies, SUSE5 participants noted that a lack of resources limited community participation in developing goals, and a lack of space limited proposed solutions. Some groups, in acknowledgement of this key barrier to multifunctional stream restoration, presented portfolios of potential solutions organized primarily by the amount of money or time required to implement them. Carrie Thompson reflects on the SUSE5 meeting:

> ". . . doing this work with true engagement as a goal will require an outlay of resources and the addition of different kinds of staff or long-term contractual partner support, but it is doable! The Feds have been doing embedded scientific engagement since the Dust Bowl, and there is no reason that these successful rural strategies can't be deployed in an urban setting."

Trust and power differentials

Differential power and lack of trust among participants can create barriers that prevent people from working together to address urban stream problems (Bos and Brown 2015). This lack of trust can be exacerbated by a lack of pre-existing relationships between community members and agency staff (Mould et al. 2020). At SUSE5, community members expressed reluctance to trust representatives of municipal government because the time and effort required for their participation had not previously led to tangible results. During the Country Club East at Monsanto case-study discussion, community members expressed frustration that the COA was not prioritizing local flooding projects because solutions were likely complex and costly. Participants also expressed concerns that ecologically based restoration projects may increase property values and displace their communities (i.e., green gentrification; Table 1) or that these projects are being considered only because the city listens to the voices of newer, whiter, and more affluent neighbors. These were not the opinions of all community participants, but these examples suggest that lack of trust between these communities and institutions could imply barriers to inclusive and equitable stream restoration.

When citizen involvement amounts only to empty ritual (sensu Arnstein 1969) rather than granting meaningful power in the planning process, the bias in power dynamics may create an environment where some voices are heard more clearly than others (Taylor and de Loë 2012). Ceding power of environmental managers and planners to community members, such as through formation of joint committees with real decision-making power or delegation of control to resident-led groups, is critical to community involvement (Arnstein 1969). However, such power shifts may conflict with institutional structures and expectations, personal biases, or solutions optimized for anticipated technical benefits (Pahl-Wostl 2006, Anguelovski et al. 2020). When discipline experts and power brokers distrust or ignore place-based knowledge in restoration planning, they impede meaningful involvement by community stakeholders and, thus, diminish the ultimate benefit to local communities (Larson and Lach 2010, Taylor and de Loë 2012, Travaline et al. 2015). Community representative Eric Paulus reflects on the SUSE5 meeting:

> "To be honest the process [SUSE5 meeting] felt to me like an empty ritual as I had high hopes the issues we looked at in Montopolis [Monsanto Case Study] would be addressed following the meeting. In the 2 years since, nothing has come of it, and with all the land-grabbing now happening in the neighborhood, I imagine equitably addressing the issues would be even harder to achieve than before. At the time, it wasn't clear to me that the symposium was, in fact, a ritual, and I left with the expectation we had created something actionable. So, it was disappointing for me. At the same time, I do not regret participating, and learned a little about how city staff and planners operate."

Differences in definition

Finally, disparate and disconnected conceptualizations of urban stream problems among stakeholders with different backgrounds and perspectives may create barriers that can be difficult to identify (Rhoads et al. 1999). Participants found some instances when they talked past one another because their conceptions of a meaningful or successful restoration differed. For example, some participants valued enhanced access to greenspace as part of successful multidimensional restoration, whereas others expressed concern that this could lead to gentrification and inequity.

Beyond the planning process, differences in how stakeholders recognize, measure, prioritize, value, and compare outcomes or how they define ultimate success may impede

the community-powered stream restoration essential for achieving sustainable outcomes (Pahl-Wostl 2006). Success in urban stream restoration is subjective and multidimensional (Yocom 2014). Failing to recognize that different people, institutions, or communities may view the same project as a success or a failure, according to their own conceptions and goals, presents a potential barrier to equitable urban stream restoration (Anguelovski et al. 2020). For example, ecologists suggested diversity of aquatic macroinvertebrates as a benchmark of successful restoration, but this was a relatively low priority for non-ecologists.

In another example, the community participants in the Boggy Creek at Jain Lane case study were critical of COA-proposed solutions. Although they acknowledged that the recommended channelization of Boggy Creek could indeed solve flooding for many residents, they noted that flood projects that retain more natural features and public access were more common in more affluent areas in the city; without them, the Boggy Creek project would not be a success. Participants struggled to effectively define the problem and project scope in a way that would integrate the disparate goals and objectives of all stakeholders. This frustration was evidenced by more variable ratings of the case study work effort by groups with community members compared with groups without them; however, participants across disciplines recognized that addressing these struggles could result in more equitable outcomes, with solutions from transdisciplinary teams ranking the highest (Bixler et al. 2022). Community representative Celine Rendon reflects on the SUSE5 meeting:

> "I felt like I was informed pretty well before entering the space and felt comfortable sharing my thoughts or pushing back on ideas I thought that were missing context from environmental justice history. Some of the sessions did feel a bit jargony, and I would have loved to see maybe some virtual models to describe what people were talking about as it relates to stream restoration."

A VISION FOR COMMUNITY-POWERED URBAN STREAM RESTORATION

Approaches to community and stream restoration

We propose that different approaches to restoration may result in different outcomes, depending on the timing and involvement of different stakeholder groups (Fig. 3A–E). Restoration focused purely on social goals (e.g., racial justice, job growth, affordable housing, safety)—here termed community restoration (Fig. 3A)—may be driven by community

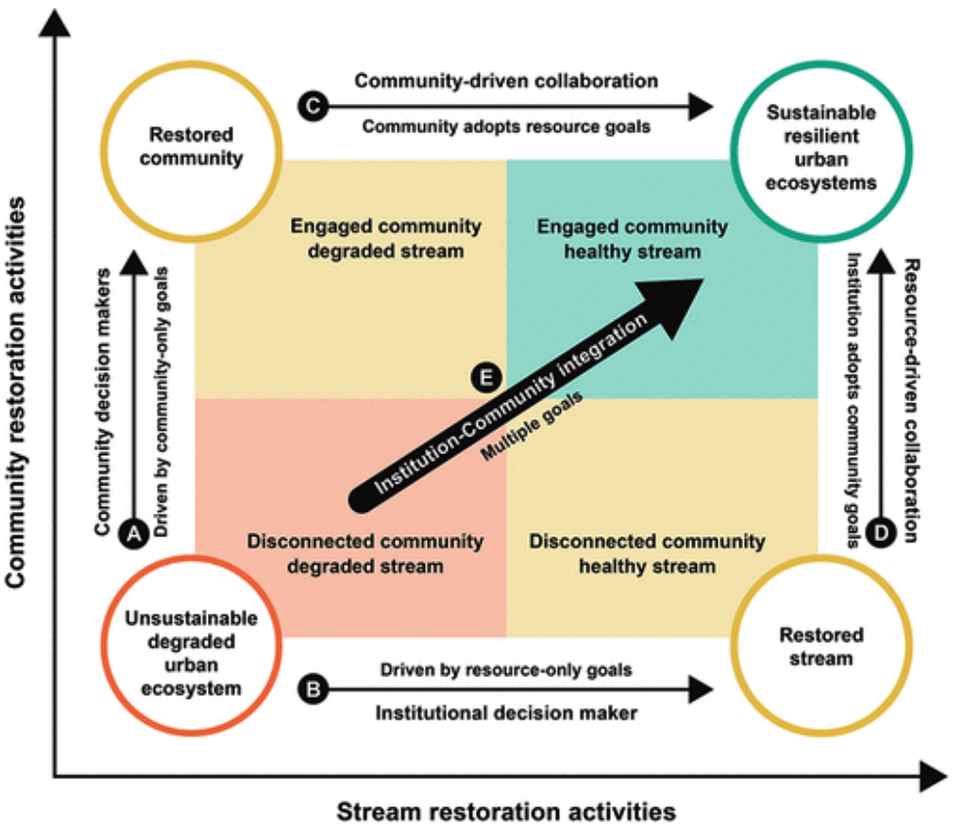

Figure 3. Diagram of 4 common routes of decision making (A–D), which ultimately use less-efficient collaborative methods, and our proposed vision for shifting degraded urban ecosystems to sustainable resilient ecosystems via institution–community integration (E), creating a more-efficient decision-making pathway. See the online edition for a color version of this image.

decision makers and may be largely independent of stream conditions (Sousa and Rios-Touma 2018). However, ignoring environmentally relevant issues (e.g., ecological stream degradation) through this pathway can nonetheless affect human communities, contributing to disease, safety issues, loss of landscape values, and opportunity costs that can undermine other community restoration activities (Sousa and Rios-Tuomo 2018, Pascual-Benito et al. 2020).

At the other end of the spectrum of restoration goals—biophysical stream restoration (termed simply stream restoration; Fig. 3B)—projects are developed by institutional decision makers with a focus on modifying instream conditions (e.g., stream stabilization, flood control, aquatic life improvement), and incorporating the input and concerns of local communities may be rare (e.g., Hawley 2018). Billions of public US dollars have been spent on biophysical stream restoration without addressing social goals (Bernhardt et al. 2005), even though omitting social goals can create inefficiencies and contribute to failure to address all the diverse drivers of watershed degradation (Christian-Smith and Merenlender 2010). Projects that do not integrate community values or build on community engagement can lead to inappropriate, nonfunctional, or failed stream restoration with poor long-term outcomes (Eden and Tunstall 2006, Murphy et al. 2022).

Although the goals of improved outcomes through community-driven and biophysical stream restoration can be pursued independently, we propose that the resulting urban stream ecosystems will be most sustainable and resilient if they include both societal and environmental considerations (Fig. 3E; Smith et al. 2014). There can be multiple pathways to achieve this outcome. For example, communities could focus on community restoration (Fig. 3A) by making efforts to create affordable housing without considering environmental resource impacts. Once housing is built, communities could work with agency managers to mitigate negative impacts of new impervious cover on streams to improve resource values (Fig. 3C). Alternatively, institutional interests may initiate a program for stream restoration (Fig. 3B) and later engage the community to define community goals within the established process (Fig. 3D). This latter example is the traditional framework of stream restoration, which embraces a technology-expert approach focused on the mission of the implementing institution with little or no direct non-expert public participation in the process (e.g., Bernhardt and Palmer 2007, Palmer et al. 2014).

The most direct route to successful stream restoration, however, may be transdisciplinary and community-powered stream restoration (i.e., Fig. 3E) that involves institutional and community collaboration in each step of the restoration effort. Following this path, institutions and communities work together to merge diverse types of place-based, cultural, and technical knowledge. Implementation then integrates community and environmental restoration actions. Under this approach, community members work with institutions to simultaneously address social and environmental challenges, endeavoring to avoid negative impacts to communities and ecosystems through restoration work.

Given that institutions with financial resources typically initiate restoration planning, we offer ideas on how to integrate the community's perspective, voices, ideas, and knowledge into that process to facilitate a balanced approach (see next section). The resulting stream ecosystem may still require maintenance because it is embedded in an urban landscape matrix that exerts complex pressures (e.g., Blecken et al. 2017). However, by combining environmental and social aspects from the initial framing of the problem in need of remediation, the resulting stream may be better adapted to changing environments and, thus, may be more sustainable and resilient to urban and social stressors. Research that compares the process and outcomes of community-powered stream restoration (Fig. 3E) to more indirect pathways could validate this approach.

We also recognize that a one-size-fits-all approach to community engagement in stream restoration may sometimes be infeasible and potentially counterproductive. Taylor (2005) suggests that the scope and investment (in terms of time and effort by both the institution and stakeholders) may be scaled by the degree of financial, environmental, social, and political risk posed by the project. A disciplined approach to assess these risks, a priori, could facilitate more efficient implementation of low-risk projects, allowing preferential allocation of resources to high-risk projects. Such an approach may have the added advantage of reducing the potential for stakeholder fatigue, where the community becomes tired of large and repeated demands on their time.

Actions to improve restoration practice

We offer 4 actions that could better involve communities in the development of stream restoration projects in pursuit of community-powered urban stream restoration: 1) understanding and empathy among all stakeholders, 2) unifying diverse voices through dialog, 3) jointly planning a set of discrete actions, and 4) implementing solutions together (Fig. 2A–D). We propose that initiating these actions in sequence, and continuing them in parallel, may help overcome barriers to community involvement in stream restoration by building trust and meaningful partnerships between diverse institutions and the many facets of community. Evaluating the efficiency of these 4 actions for improving community involvement in urban stream restoration could lead to improved outcomes. Omission of any actions, or foregoing the engagement of strong community stakeholders, may compromise the integrity of community or stream restoration outcomes (Crawford et al. 2017).

These actions are offered as generalized guidance rather than prescriptive steps because the appropriate tools, methods, and applications may be most effective when tailored

to the local social–ecological context. Below, we describe each action and suggest options and examples for restoration practitioners to consider (Table 2).

Understand and empathize The ability to appreciate the feelings of different people working together on stream-management projects can be reached by being open, exploratory, and divergent in discussions and interactions. Deeper understanding and empathy among participants from institutions and communities may help develop trust and create a collaborative environment, particularly if the community's feedback is integrated into the decision-making process. Understanding the community implies listening to and learning about its people's culture, history, stories, values, concerns, hopes, aspirations, ideas, and dreams. Through those narratives, water managers and institutions may learn the motivations and values that may trigger support, apathy, or rejection of proposed actions. A culture of understanding may help identify and acknowledge the history and legacies that can weigh heavily on the community. These legacies may be powerful drivers of how a project is viewed and whether the project can even achieve its intended goals. For example, in the Fort Branch Creek at 51st Street case study, the transdisciplinary team discussed the importance of listening to the history of Black and Latino community members who have lived in the neighborhoods within the basin: how they connect, if at all, to the creek running along

Table 2. Key engagement process components that may help overcome barriers and achieve better urban stream and ecosystem outcomes.

Actions to take	Examples of actions
Understand and empathize	Listening sessions
	Cartoon drawing, storytelling
	Coffee conversations
	Perennial relationships before the project occurs
	Learning the community's narrative and stories
	Joint field visits to see sites and discuss problems together
Unify through dialog	Vision statement
	Focused team—A small team of individuals representative of various constituencies and perspectives who have the time or resources to meet and think deeply about a plan or project
	Advisory board—Representatives who have less time or resources to think deeply but who can objectively engage and evaluate at key milestones
	Broader organizing platforms—Canvassing, surveying, public meetings, etc. to facilitate a transparent process and ensure the ideas from the smaller group are representative of the broader community. One might envision cases where broad platforms may circumvent the need for focused-team input altogether
Plan jointly	Iterative expert-citizen methods
	Regular meetings with small teams
	Milestone meetings with advisory board
	Focus groups
	Community workshops
	Outreach via community networks (e.g., churches, schools, neighborhood groups, etc.)
	Social media
	Surveys and canvassing
	Traditional National Environmental Policy Act-style planning (decide, announce, defend)
	Deep engagement with a highly structured process such as structured decision making
	Shallow but highly democratic engagement, such as a design competition or vote
Implement together	Traditional operations and maintenance (long term and perennial)
	Adaptive management with representative structure
	Citizen monitoring and agency action
	Citizen-supervised operational committee (big projects only)

their backyards and how their thoughts about the channelized vs more natural creek sections may affect their engagement in restoration of the creek.

Unify through dialog Bringing together disparate views into a shared vision that identifies what is most important and actionable does not require a consensus opinion. Rather, it encourages concessions and acceptance of a shared path forward—even if the path does not resolve all issues. Converging conversations can bring people together around priorities, possibilities, resources, and the scope and scale of the project, in addition to opening perspectives to alternative suitable options. These conversations can help identify how agency, community, and technical stakeholders could be involved, reveal knowledge and resource gaps, and identify partners who may help fill those gaps. As these alliances are built, mutual understanding can help develop and maintain connectivity, illuminate benefits, costs, and opportunities, and provide a safe environment where stakeholders can work together through successes and failures while acknowledging where they may accept compromises. In the case of the Boggy Creek at Jain Lane case study, creating a safe crossing for students was a priority for community members, whereas a trail system connecting north and south sections of the creek was important for the COA transportation department. In this example, community use of the undeveloped parkland that sits between the students' school and the creek could engage the parks department, bringing a key stakeholder to the table, and a holistic approach to stream restoration could provide the impetus for integrating different priorities and potential partners into a unified process. Community representative Frances Acuña reflects on the SUSE5 meeting:

> "Participating in this meeting took me to another level of understanding. The different groups and their projects taught me that no matter what level of education one has, the expertise one brings to the table is unique whether it comes from the most highly educated person or the most humble and vulnerable person in the room. It was a little shocking to realize that in the times that we live, we still lack cultural knowledge and community understanding."

Plan jointly Joint planning can help clarify and document the responsibilities, deliverables, and schedules of an urban stream restoration project. The planning process, particularly its transparency and equity, helps to establish expectations and keep communication channels open and flowing. As with the other actions, active participation of all relevant stakeholders throughout the process can lead to more buy-in and, ultimately, greater project success (Smith et al. 2016). Effective planning processes begin with a unified problem statement, followed by identifying fundamental objectives and actions that address those objectives (Gregory et al. 2012). The planning process may be iterative, revisiting the problem and objectives as stakeholders weigh alternatives and ensure all concerns are addressed. The Boggy Creek at Cherrywood case study exemplified the importance of integrating stakeholders into the planning process early because of its complex mix of drivers and barriers. The initial project driver of flood complaints was set aside because of participants' interest in erosion, *Escherichia coli* contamination, and ecological restoration, each of which had its own strong advocate. The barriers of the project were also varied—costs, railroad lines, an interstate highway, buried utilities, and conflicting neighborhood plans—the combination of which highlighted the need for a comprehensive and unified plan for advancing solutions. Eric Paulus reflects on the SUSE5 meeting:

> "I know people who actively advocate against improvement projects like creek restorations, trails, etc. because they know it's either a result of or harbinger of gentrification. They aren't wrong. I would like to see investments made to ensure creeks are clean and functional rather than these enormously expensive, elaborately designed amenities and redevelopment projects."

Implement together This action involves putting restoration plans into effect, including project delivery and ongoing adaptive management and education/outreach after the project is completed. This phase can be an opportunity for deep community engagement and buy-in; however, it can also result in trust loss if communities are excluded (Dyer et al. 2014, Anguelovski et al. 2020). SUSE5 attendees and moderators identified accountability and a commitment to transparency as critical components of co-implementation. The implementation phase may take a wide range of pathways, depending on scope and scale of the project, but a well-established, transparent decision-making structure and process with a mutually agreed-upon schedule and funding plan as well as opportunities for engagement of all parties may help ensure success. Opportunities to hire community members to execute and steward restoration (e.g., public outreach, interpretative creek walks, educational outreach to schools, tree planting, revegetation, and invasive species control) can have direct and indirect long-term benefits, leading to increased acceptance of such programs in the US (e.g., Project Groundwork, https://www.groundworkproject.com). Building flexibility and adaptability into the implementation phase may allow for stakeholders to understand and support alternative actions and responses if implementation does not go as planned. The Fort Branch Creek at 51st Street transdisciplinary group discussed multiple opportunities where the implementation of the project could provide economic opportunity for the neighborhood, beyond just

the COA's consultants and contractors. Frances Acuña reflects on the SUSE5 meeting:

> "This [workshop] opened my eyes to why there is always a disconnect between city and community's trust and understanding between each other. Since this meeting, I started changing my strategies when working with the city and with community leaders."

STRATEGIES FOR SUCCESSFUL IMPLEMENTATION

Diverse community representation in stakeholder-driven decision making may face several of the barriers previously discussed. Here, we explore some strategies for overcoming those barriers by implementing 1 or more of the above actions we have identified to improve restoration practice. This discussion is neither exhaustive nor prescriptive, but our collective experience from the SUSE5 case studies illustrates some successful strategies for addressing the barriers challenging a given project. These strategies would benefit from further research to test and validate their effectiveness, more broadly, in overcoming barriers to community involvement in stream restoration. We believe, however, that they offer a useful framework for making immediate progress.

Intentional engagement

Institutions must clearly and transparently commit to social engagement in order to overcome barriers to trust and understanding. Agencies may have staff with facilitation and engagement expertise who can assist with communication between engineers, ecologists, and community members, and they must prioritize and formalize this practice. Proactively and consistently building long-term trusted relationships can be critical to the engagement between community and institutions in environmental endeavors (Bos and Brown 2015). If performance indicators that recognize and reward community collaboration are established at the outset, they may reduce the primacy of purely technical outcomes while enhancing the likelihood of broadly supported and sustainable outcomes.

Achieving meaningful engagement of a diverse mix of communities (Usher et al. 2021) may require substantial time investment from both institutions and citizen participants. Community stakeholders may lack technical training in stream ecology and urban engineering that could limit their participation (Crawford et al. 2017). However, practitioners with technical expertise working alongside (and training) community members may achieve greater community involvement through iteration and increased local skills, ultimately increasing community members willingness to trust and engage with these agencies (Bos and Brown 2015). Deep community engagement in the co-design of stream restoration may, thus, prove to be a long-term investment with valuable long-term benefits, albeit high initial costs (Bice et al. 2019).

Appropriately compensating community volunteers for their learning time, just as employees of the institutions are, can also support engagement while contributing to resource equity and fairness. For example, a National Science Foundation award (DEB-2012128) was used to provide stipends to community member attendees at SUSE5. Financial compensation of community members also demonstrates that community perspectives are valued and, thus, may further promote trust and empathy.

Additional benefits accrue from genuine community engagement. These may include the resources that engaged stakeholders will bring. In addition to the potential for voluntary labor in restoration, strong community engagement may, for example, increase access to funding from other agencies to support secondary benefits (i.e., beyond ecological restoration) to the community, such as recreation, urban microclimate amelioration, crime-reducing landscapes, or flood mitigation. Overall, we suggest that intentional engagement is a prerequisite for implementing any of our identified actions to improve restoration practice. Celine Rendon reflects on the SUSE5 meeting:

> "I truly believe community stewardship is foundational to ensure positive environmental and social health outcomes. I do think multiple perspectives are necessary, and that professionals in this work should talk to, not at, people in the community where this work is needed. I also think more context [is required] of how watershed management has totally devastated some of the natural streams and rivers in communities where low-income folks and people of color live. How do we ensure we address the harm that has been caused? How do we use that analysis to inform better relationship building with people in these communities?

Diversity of perspectives

With community engagement, a more diverse and creative range of priorities can emerge in planning and decision making (Smith et al. 2016, Hawley 2018, Campbell-Arvai and Lindquist 2021). Although such diversity can offer the potential to discover innovative options, its inclusion can also cause delays and may create frustration from participants, albeit for different reasons. For example, those planning participants who consider themselves to be pragmatic may understand that not all creative approaches are practical. In addition, community perspectives and priorities can themselves be diverse, providing further potential for complexity and conflict even among different community participants (Anguelovski et al. 2020).

As noted by many of our community participants and collaborating reviewers with Indigenous heritages, many Indigenous cultures see no separation between human communities and natural ecosystems (e.g., Djiniyini 1985, Booth 2008, Chen et al. 2016). Although integrating these diverse and

potentially diametric perspectives may be challenging, methods for capitalizing on and guiding divergent thinking are well established in fields as varied as education, arts, and business (Beaty and Silvia 2012, Zhang et al. 2020). Involving Indigenous cultures in river restoration not only offers the potential to redefine relationships with Indigenous communities but also may provide a connection to the powerful local knowledge of landscapes and river systems that these communities possess (Fox et al. 2017, McMillen et al. 2020). Building the trust necessary for this Indigenous knowledge to be shared, however, may require careful attention to the relationships between institutions, Indigenous groups, and broader society to overcome the barriers arising from trust and power differentials (Burnette and Sanders 2014, Jackson 2019).

Training for all

The most successful examples of community-powered stream restoration actions occur where community members and technical experts have specific engagement training that allows them to more effectively participate in the process (Cuthill and Fien 2005). Ensuring that the project plan allows for this engagement also has the benefit of building trust (Jami and Walsh 2017), which can facilitate participation not only for the specific project at hand but also for subsequent projects.

Ultimately, investing in direct engagement of personnel and prioritizing skills and training for institutional staff may facilitate these deeper relationships that can create trust among participants, particularly where training and capacity-building programs are tailored to their community. For example, training in recognizing implicit bias and understanding land-use history, development and displacement practices, disenfranchisement, disservices, financial inequality, and historic and contemporary land-ownership dynamics may increase empathy of individual staff and help to build trust with the community (Wang et al. 2021) as well as influence institutional and project objectives. This improved understanding can help overcome barriers of mistrust and misunderstanding between institutions and the community.

Mutual learning can be key to helping both community members and institutional experts make the most of the opportunities resulting from engaged stakeholder processes. A commitment to mutual learning may require contribution of resources from all parties that go beyond conventional outreach and education efforts, including openness to the mechanisms, challenges, and opportunities of working together.

Transparent decision making

A transparent decision-making approach may minimize the risk of potential disagreements in desired outcomes and address conflicts if they do arise. Such transparency may be important for gaining consensus with all project stakeholders in the final selected set of goals. By its very nature, genuine engagement can initially create uncertainty about the final outcomes because the outcomes cannot, by definition, be tightly defined before the community is engaged and can contribute to the project's goals. The need for engagement and transparency is particularly acute, however, where historical development practices, such as lack of or biased floodplain regulations, inadequate drainage designs, and insufficient maintenance, have contributed to contemporary flooding issues. These practices disproportionately affect historically underserved communities (Jain and Bazaz 2020, Moulds et al. 2021), and they leave a legacy of distrust that can only be overcome with a genuinely engaged decision-making process. The Country Club East at Monsanto Drive case study is an example of this legacy of underinvestment and inadequate infrastructure: the proposed solution was complex, costly, and developed without community input, and the 3 SUSE5 community participants did not believe it addressed their priorities.

CONCLUSION

Collaboration is at the heart of community-powered stream restoration efforts, but multiple barriers to achieving collaboration exist within most restoration programs. Intentional examination of these barriers through the SUSE5 symposium has led us to a proposed vision for guiding institutions to overcome these barriers and address the interests of the community through collaboration (Fig. 3A–E). Implementation of this vision will require intentional engagement, allowing participants in stream restoration projects to understand and empathize with different points of view and priorities, unify disparate groups of institutional and community stakeholders, jointly plan with shared decision making to achieve equitable outcomes, and implement together to establish long-term trusting relationships and continued partnerships.

We recognize the real difficulties that individuals and institutions may have with a community-driven approach to restoration, which can change existing power structures and the internal processes that many agencies may use to identify and implement stream restoration projects. Early efforts could potentially yield conflict and reticence from communities who perceive that their power and trust in institutions have been eroded. Successful collaborations may need to begin with a recognition of the diverse challenges involved and with institutions fostering the willingness to transform their structures to facilitate community participation. In the end, however, restoration that involves human communities may be essential to achieving ecological improvement. Additional research that compares the outcomes of traditional and community-powered stream restoration is needed to confirm this approach; nonetheless, our experience at SUSE5 leads us to the conclusion that the more communities are woven into restoration decisions and actions, the more sustainable

and resilient the stream ecosystems and their human communities will be. Frances Acuña reflects on the SUSE5 meeting:

> "I believe this paper can help researchers, scientists, and highly educated people to understand the complexity and the importance of community integration. This opened my eyes to why there is always a disconnect between city and community's trust and understanding between each other."

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