Mechanisms for engaging social systems in freshwater science research

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Abstract: Transformative research in freshwater ecosystems requires successfully engaging an array of stakeholders. Local community members are experts of the social and ecological systems in which they are embedded and can improve scientific research in many ways. We outline several steps for researchers to engage local experts specifically by focusing on making their projects meaningful to participants. Based on the authors' collective experiences of engaging communities in freshwater research, we offer 3 sets of practical strategies for facilitating public engagement in natural resources research. We outline 3 techniques for building mutuality with the local community and local experts, 2 strategies for building and maintaining relationships, and 5 key efforts that help research teams achieve reliable attendance at meetings. Involving locals is not merely a means for arranging access to valuable research sites or for gathering data. Local experts can inform scientific investigations of the ways local social and ecological systems interact, improve the communication of science, and enrich the experience of field research.

Key words: stakeholder engagement, public participation, citizen science, community science, participatory research, social–ecological systems, sustainability science, human dimensions of natural resources, science communication, integrated water-resources management, science–society gap, policy

Imperative for human life, freshwater systems are inherently entwined with social systems. Advancing freshwater science requires understanding human behaviors beyond treating social factors as disturbances, rendering sociocultural understandings for the convenience of modeling, or merely engaging community members for their ability to gather or provide access to data (persons as instruments). When scientific research involves shared public resources—like fresh water—the door morally and politically swings open to the public voice, requiring engagement of communities that is mutually beneficial to researchers and the general public (Beck 1992, Fischer 2000).

Engaging communities can be critical for gaining insights into factors regulating water quality, hydrologic processes, and ecosystem characteristics (Carr et al. 2012), but cultivating community participation presents challenges. Scientists

studying freshwater systems often depend on communities to obtain data sources or access to private properties to collect new data. However, acquiring access to private property can be problematic when landowners have no apparent reason to cooperate, and no matter how politely explained, researchers' needs do not always compel local cooperation. Community science projects emphasizing crowd-sourced data are also challenging because they require high participation rates, which can be difficult to acquire, to maximize the utility of data and ensure the transferability of research to other settings (Lowry et al. 2019). Put simply, it is not easy for research teams to secure community engagement in science, particularly at levels that advance research goals.

In our experience, useful public participation in science is not a function of simply asking for assistance but a function of relationships of trust and respect earned over time. The greatest barrier for engagement is perceived irrelevance of the research to community members' daily lives (Cash et al. 2003, Clark et al. 2016). Researchers must commit themselves to cultivating on-going relationships with a broad array of community members (Burdett et al. 2021, Golladay et al. 2021), and these relationships cannot solely be based on researchers' needs. Instead, relationships should be built on mutual understanding that emerges when research design and execution are informed by community members' place-based experiences.

We argue that any efforts toward public engagement in scientific study should begin by considering participants as local experts with valuable experiential insights regarding environmental processes and by building relationships with key members of the community (Kemmis 1990, Honadle 1999, Fischer 2000). Public engagement in management of freshwater resources has been shown to provide a suite of contributions (beyond gathering data) when project managers focus on relationships (Hall et al. 2016). By successfully engaging a small number of local experts, researchers gain access to multiple social networks and insights on various community dynamics that could either facilitate or hamper the research project's overall success (Burdett et al. 2021, Golladay et al. 2021). This approach acknowledges the mechanisms that intertwine social systems with freshwater ecological systems.

Below we outline several steps for engaging local experts by focusing on how researchers can make their projects meaningful to participants. These steps are based on literature from public participation in environmental policy, community psychology, and communication theory. The specific suggestions are drawn from our collective experiences of engaging local experts across a variety of community science projects, water-resources planning activities, and sustainable community collaborations.

IDENTIFYING MUTUAL AIMS AND POTENTIAL PARTICIPANTS

Long-term residents, such as farmers, ranchers, homeowners, and other community members, are acutely aware of the natural and social resources they depend upon for their quality of life. By virtue of everyday life, they accumulate tacit, experiential, and passed-down information that cannot be readily known to researchers (Wondolleck and Yaffee 2000). They are aware of both overt and underlying motives and functions operating in their social context—expertise that is essential to understanding how their community will respond to research efforts. A freshwater researcher will benefit from cultivating relationships with residents who can serve as experts regarding local social complexities. However, research projects will likely engender local participation only when the projects are meaningful to local experts (Marschütz et al. 2020). The project goals and interactions with the researcher(s) must fit with local values and experiences, leaving one to ask: how can scientists tap into local place-based expertise? We have found that effective public engagement in science research requires treating the social system as an equally interesting site of inquiry (Hall et al. 2015, 2016, 2017, Hopfensperger et al. 2021). In addition, a primary goal should be to establish mutual aims that are important for both the local experts and the research team (Gray 1989, Fisher et al. 1991, Daniels and Walker 2001, Walker 2007).

To achieve mutuality, it is important for researchers to deliberately and methodically study communities prior to and during the engagement. For instance, freshwater researchers should commit to documenting and understanding how locals interact with, conceptualize, and value community resources. Derickson and Routledge (2015) illustrated how researchers can triangulate their research questions by identifying questions that simultaneously aim to produce academic knowledge as well as address the practical interests and objectives of the engaged public. These research questions will consider: 1) what are the prevailing theoretical questions being advanced in the discipline, 2) what public/institutional projects are served by these questions, and 3) what is it that non-academic collaborators want to know? By making efforts to understand what matters to locals, researchers can better communicate the research goals to potential participants and shape the scientific products to meet the needs and interests of the immediate audience—local resource users (Lejano et al. 2007, Chang et al. 2020). We suggest 4 strategies as essential for beginning to build mutuality with the local community and local experts: 1) use Google Alerts, 2) keep lists of contacts, 3) identify the right participants, and 4) conduct member checking.

USE GOOGLE ALERTS

Google Alerts is a content-change detection and notification service. It pulls all material posted online related to a search term—akin to newspaper clipping services of yesteryears. At a designated frequency (e.g., daily, weekly), the subscriber is sent an email that lists every web reference, such as newspaper articles, magazine stories, events, press releases, and webpages, containing designated search terms (e.g., "Mill

Creek"). Reading these materials gives the research team important insider information about events in the study community and timely topics of concern, providing insight into what matters to the community. Further, local newspaper articles are resources for important proper nouns, such as colloquial place names and names of key persons to contact. Designating a team member to curate and send the most insightful and authentic materials to the team saves time. This tool equips researchers to be better conversationalists with the local community, despite geographic distances, helping researchers to gain a better sense of the local environmental conditions. Through these alerts, we have become aware of dam breaches, flooding events, fish kills, ice jams, and awards given to our collaborators. This information has allowed us to make phone calls to check on equipment in the water, console or congratulate project partners, and adaptively manage research aims.

Keep a database of contacts

When the project is in its earliest planning phase, scour the internet to find relevant resource-dependent businesses, non-governmental organizations (NGOs), government offices, and landowners. Build a spreadsheet of expert contacts to organize potential participants' email addresses, phone numbers, websites, and relevant notes, such as "Pat's friend" or "organized the 1st annual Riverfest in 1998". Preparing this spreadsheet before entering the field allows the research team to immediately engage with the local community and to fill in important details about the social system as additional information is learned onsite. The spreadsheet of contacts also allows the research team to quickly email or call local experts and update key details as the social system changes. We always re-read our spreadsheets prior to entering the field to keep names fresh in mind, especially if months have passed between field visits. We also use these contact lists to recruit for meetings, events, and for soliciting feedback on drafts of products (see below).

Identify the right participants

In addition to enlisting interested members of the public, engagement efforts should target those who frequently use or benefit from the shared freshwater system. This may include resource-relevant business owners (e.g., fishing guides, livery, campground and bait shop owners, waterfront restaurants and hotels, chamber of commerce staff), municipal and county government officials, waterfront landowners, and environmental NGOs (Golladay et al. 2021). Among these local experts, engaging well-known opinion leaders or those active within the community is critical (Moorhouse and Elliff 2002, Uittenbroek et al. 2019). To use the metaphor of the wheel from social-networking theories, these are hub people with significant social or political influence. They are the most knowledgeable about the mechanisms and structure of the social system and often serve gatekeeping functions by providing access to key persons, community groups, informa-

tion, or sites. They will tell you who else to involve. Working with gatekeepers requires attention to how your research can further their interests (Trickett and Espino 2004, Cornwall 2008, Ellard-Gray et al. 2015).

Avoid being persuaded that larger quantities of persons engaged is meaningful. Engaging the right local experts within a social system is paramount. If the project is seen to be meaningful to the local expert, they will engage others in a relevant manner (Hall et al. 2012). Many projects may reach large numbers of the general public without gaining the social acumen needed to leverage desired project outcomes, but targeted engagement is almost always a better use of resources (Hall et al. 2016).

Informal conversations with stakeholders can result in learning by both science teams and communities; however, the most comprehensive way to learn how the social system values the freshwater resource is to formally interview key local experts face to face (in situ or virtually). Unlike survey instruments administered from afar, interviews honor local experts' knowledge by the giving of researchers' time and providing interviewees opportunities to ask questions of the researcher (Hall et al. 2012). On a project about the Yellowstone River in Montana, USA, our interviews with key experts signaled to communities that important planning conversations about the freshwater system were occurring. Soon thereafter, key persons began contacting us and requesting to participate in the study (Gilbertz et al. 2011). Interviews also offer the ability to speak at length without word-limit restrictions or restrictions of responses by predetermined scaled instruments (Creswell and Poth 2018). Most importantly, interviews allow local experts to speak freely in their own words. Local vernacular reveals how people conceptualize freshwater systems and provides researchers with alternative, locally sourced ways of communicating technical information.

Interviews can begin with the list of contacts and can take several different forms. The most formal of these conversations are audio recorded, transcribed, and analyzed. Conversational (or ethnographic) interviews function to build relationships, rapport, and trust (Hall et al. 2012). Informal, non-recorded interviews can be effective when researchers immediately reflect upon the conversations via fieldnotes or journaling about what was learned. Regardless of the type of interview method used, interviewing local experts requires training and, for university employees, approval from an Institutional Review Board for working with human subjects. By collaborating with the US Land-Grant University System's Cooperative Extension Service (7 USC § 3221) or with social scientists familiar with environmental science research, such as human dimensions of natural resources, researchers can improve the efficiency and reliability of interviewing.

Conduct member checking

Seeking feedback is a useful practice to ensure that assessment of the social system accurately reflects the values,

aims, and desires of the community of local experts. Present what you think you heard back to a selection of key informants and ask, "Did we get it right?" The value of this practice, termed member checking, is that it validates participant-supplied findings (Lincoln and Guba 1985). It also provides an additional opportunity to have important conversations about mutual goals between local communities and the research team. For example, "We heard local residents describe a need for better information about floodplain development in order to operate their businesses. Are we correct in thinking that this is a community concern that our hydrologic model could address?"

BUILDING AND MAINTAINING WORKING RELATIONSHIPS

Every member of a research team should view interacting with local experts as fundamental to the work being done. However, a great deal of effort is required to build and maintain good working relationships, and the time-constrained nature of research may cause the relationship-building process to become rushed (Senecah 2004, Stewart and Sinclair 2007). Here, we recommend 3 important strategies for building good working relationships between the research team and community members: 1) designate a point person, 2) provide advance notice of visits, and 3) communicate via locally used channels.

Designate a point person

To ensure important social-system data are not lost, a point person should be designated as responsible for communicating with stakeholders. This team member serves as the point of contact for stakeholders, providing quick replies to requests and inquiries, giving progress updates throughout the project's major stages, and convening events, such as informational meetings and social events like dinners or happy hours. The point person also serves as a media contact and communicates the science for public audiences. For researchers who may not already be comfortable in this role, there are many tools to help develop skills for communicating science and speaking with the news media (Baron 2010, Montgomery 2017, see Hopfensperger et al. 2021).

In addition to a designated point person, set the expectation that each team member must be prepared for, and responsive to, public interactions and requests, especially during any project that engages local experts in citizen science or researches a beloved place. For example, graduate student field researchers inevitably will be approached in the field by locals, and they need to be prepared for friendly and professional interactions. They should practice talking points about the research, its importance to shared community values, and how the project will help them professionally. Lead researchers should commit to attending community events, giving public talks at the research site, and being available by email and phone to key community collaborators.

Give advance notice of visits

When planning field research visits, inform key partners well in advance. This courtesy ensures that time is used productively. With advance notice, local experts may want to arrange access to additional sites. They may wish to set aside time to visit the team in the field or to socialize with the team following a day of fieldwork. This time together is important for learning more about the needs of the social and ecological system. Face-to-face time with local experts makes it easier to pick up a phone and notify community members of upcoming meetings and field visits or to simply ask for advice for getting something done.

Communicate via locally used channels

For citizen/community science or other projects highly dependent upon public involvement, learn what channels of information reach your target audience. Take advantage of opportunities to communicate to local experts via familiar sources, such as local newspaper press releases, local organizations' newsletter articles, or talks at community events. Communicate progress updates as you would with other project partners, such as through academic papers, websites, or annual reports to funding agencies.

GETTING PEOPLE TO MEETINGS

A common challenge for researchers engaging community experts is recruiting participants who actually show up to meetings and events. Governmental natural resource agencies frequently cite attendance as a major concern for public involvement in resource management (Daniels and Walker 2001). Recruiting hard-to-reach (geographically distanced, social elites) and vulnerable (disenfranchised, subject to discrimination) populations can be particularly difficult (Ellard-Gray et al. 2015). We have found that there are 5 key efforts that help research teams achieve good attendance at meetings: 1) define and communicate a clear meeting purpose, 2) define and target a group of attendees, 3) plan meetings that are convenient and comfortable for local experts even if that means your team might be inconvenienced, 4) recruit for every meeting, and 5) manage the meeting agendas and be attentive of participant needs.

Define and announce a clear purpose

Defining and communicating the purpose of meetings, and adhering to the stated meeting purpose, are key for building trust with a community and for encouraging experts to attend meetings. We have seen that even a single failure to adhere to an announced purpose for convening will be off-putting and difficult to overcome when calling for local experts to attend future meetings. It is especially frustrating for attendees when they think they will have opportunities to provide input, only to realize the information will only flow 1 way: from the science expert to the local expert. Fortunately, we have also found that local experts are likely to

attend meetings when they know why the meeting is being called and when they trust that the meeting organizers will not deviate from the defined purpose (Lehmann-Willenbrock et al. 2018). We advise being as explicit as possible when announcing meetings and communicating clearly whether they are informational meetings or ones where local input will be solicited (Willems et al. 2020).

Identify a targeted group of local experts

Defining and targeting a group of local experts will elicit a greater number of, and more useful, meeting attendees than relying on public announcements to inspire people to attend. Although public announcements of research meetings may be legally required in some circumstances, many resource professionals find that these announcements rarely yield many public attendees. Avoid depending on public announcements as the only means of getting people to attend meetings. Often, it is more useful to define the type of local experts who will be valuable for the purpose of the meeting and then identify individuals who should be recruited. A variety of sources may be helpful in compiling a list of recommended attendees. We advise approaching government personnel, locally influential groups, and local elected officials to ask for guidance. These sources can typically provide names and phone numbers of key experts they recommend for your meeting. We recommend establishing, for each meeting, a spreadsheet of names, phone numbers, notes about why each person is a good recruit, and information about who provided the recommendation.

Arrange for a convenient and comfortable meeting

We advise scheduling meetings for the convenience of the attendees and providing refreshments (Lehmann-Willenbrock et al. 2018). Meeting attendance will be enhanced when meetings are scheduled at a time and place convenient for attendees. This may require that meetings occur in the evening or even on the weekend. Your list of attendees may help you determine when and where to schedule the meeting, and you can directly ask them what times work best for their schedules. Also, be prepared to offer attendees refreshments. Caffeine and sugar support good attention spans.

Recruit for each meeting

With your purpose defined, meeting arranged, and database in order, begin by calling each of the local experts to invite them to the meeting. We advise active and direct recruitment; that is, begin with personal phone calls rather than email or a mailed letter. Be prepared to quickly define the purpose of the meeting and how their attendance and input will be valued. Recruitment will be more successful if you have permission to use the name of the person who recommended this local expert. For instance, the 1st call is more successful when one can say (even in a voice message), "Hello. I'm calling because Commissioner Jones gave me

your name and number." It is even more ideal if the person who made the referral contacts the potential recruit first, setting the stage for your call. You will likely need to leave messages and make follow-up phone calls. We have found the best success by making the 2nd call in the evening, with attention to customs around eating times and never after 9:00 pm unless requested by the recruit. After a potential attendee has agreed to participate, always contact them with a reminder of the meeting place and time. It is also important to use each recommended local expert as a source of other experts, which is known as snowball sampling. Ask each contact, regardless of whether they can attend or not, for additional contacts they suggest for recruitment. Then update your spreadsheet with this additional information.

Yes, this recruiting approach is laborious and cold calling strangers is uncomfortable, but this approach works. Remind your team that freshwater resources matter greatly to community members, and by taking the time and effort to personally call community experts, they are likely to receive positive responses and recruit truly useful meeting participants. Also, remember that when engaging with a social system in a community, such as when recruiting for meetings, researchers often get just one shot to earn trust and participation.

Manage the meetings

Attendance at subsequent meetings may be influenced by participants' experiences at previous meetings. Above, we advised that you adhere to your stated purpose for the meeting. You should also be prepared to intervene if participants attempt to redefine the meeting's purpose. Veering from the announced purpose is risky and should only be done when the following conditions are met: 1) organizers can successfully negotiate and address the proposed change in purpose, and 2) the overwhelming majority of attendees wish to shift the focus of the meeting. Otherwise, agree to arrange a meeting where the newly proposed purpose will be addressed, with the recognition that you must fulfill that promise.

We also recommend limiting the number of topics and activities to avoid causing information overload or participant fatigue. While it may seem advantageous to do more at each event, this approach is seldom truly productive (Gilbertz et al. 2019). Learning theory is clear: a person can only process 5 to 7 new ideas under optimal conditions (Bandura and Walters 1977). Be realistic about time and information limitations while developing content and activities. During the meeting, it is also important to maintain and encourage a positive tone. If participants find a meeting too stressful, that experience is likely to deter their attendance at future meetings (Lehmann-Willenbrock et al. 2018). One need not be a comedian or entertainer, but consider modeling people you know who maintain their good humor even under crisis. People tend to remember how they felt leaving a meeting as

much as they remember the purpose of the meeting. One of the best predictors of future attendance is the experience of the last meeting.

CONCLUDING REMARKS

This essay identified 3 sets of practical strategies for facilitating public engagement in science. These strategies push researchers to move beyond traditional approaches to public engagement by recognizing local stakeholders as experts of the intertwined physical, biological, and social systems in which they are embedded. Local participants are not merely a means for arranging access to valuable research sites or for supplying data; rather, they can inform scientific investigations of the ways local social and ecological systems interact. For example, a local expert might have insight into how a stream's hydrology is shaped by a specific development policy established by local community norms in the 1970s (Hall et al. 2013, 2015). Local experts can also link local interests and understandings with research goals and outcomes. Their place-based expertise provides researchers with critical information, often missed by ecological experts who come to field sites as outsiders. Building and maintaining relationships with local experts allows researchers to identify opportunities for mutual aid, where the objectives of both parties are enriched and extended in novel and productive ways. By engaging the social and cultural dynamics of societies and sciences (see Anderson et al. 2016, Pratt 2018), socioecological researchers can nuance and deepen our understanding of the ways in which human communities and freshwater systems are intertwined.

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