Linking Environmental Research and Practice

LESSONS FROM THE INTEGRATION OF CLIMATE SCIENCE AND WATER MANAGEMENT IN THE WESTERN UNITED STATES

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Contents

Introduction

Natural resource managers and policy makers have a significant stake in environmental research being done in universities and government labs across the world. At the same time, many scientists are becoming more interested in making their research results applicable to real-world planning and decision making contexts. As a result, collaborations between environmental scientists and a variety of stakeholders have increased over the last several years, providing the opportunity to look back at these experiences and see what has been successful and to make suggestions about best practices for future interactions. We have therefore put together this handbook to explore this terrain, focusing on lessons learned about motivating, building, and sustaining a successful collaboration between researchers and practitioners to address complex environmental problems. The lessons are drawn from research exploring interactions between the climate science community and water management in three western US cities, but the information in this handbook is meant to be useful to both scientists and practitioners working on a range of environmental issues.

Key Terms used in this Handbook

In preparing this handbook we chose to adopt the term **practitioner** to describe those outside of the academic science community who have a stake in environmental research. We are using this term in the broadest sense to include resource management professionals, planners, and any decision makers who have a professional interest in environmental research that is responsive to the needs of their communities.

Similarly, we frequently refer to **science-management, science-practice**, and **scientist-practitioner** collaborations and interactions. As with the term practitioner, we are using these phrases as shorthand for a large variety of collaborative interactions that bring together the members of the research community and members of a non-academic professional community who has a stake in environmental research.

Finally, we also make several references to the **boundary** or **divide** that separates these communities. Here we are characterizing some of the practical differences between these communities in terms of diversity of approaches, ways of gathering evidence, and problem solving techniques. In very broad terms, we are referring to the cultural differences that exist between researchers and practitioners.

Goals of the Handbook

Efforts to better connect scientific research with people and organizations involved in environmental decision making are receiving increased interest and attention. Some of the challenges we currently face, however—including complex questions associated with climate change—are unlike most of the environmental issues encountered in the past because of their scale and scope as well as the fact that they have no easily agreed-upon solutions. Focused research on the intersections between environment and society has provided substantial insight into dynamics of large-scale environmental change and the related impacts on people, natural resources, and ecosystems, yet our ability to connect this research to real-world decision making remains limited. What is clear is that addressing these complex environmental problems requires broad cooperation between scientists and those who may apply research results in decision making, but there are few templates for guiding the growing number of scientists and practitioners now engaging in this kind of cooperative work. We believe, therefore, that a close look at the direct experiences of those who have been working to integrate science and practice is needed to provide lessons learned and a set of practical suggestions for others doing integrative work to address complicated environmental challenges. This handbook is designed to help fulfill this need.

SPECIFICALLY, THIS HANDBOOK WAS DESIGNED TO:

1 **Help individuals and organizations interested in science-management interactions better understand the nature of these interactions in practice.**

2 **Highlight the importance of consistent, ongoing interactions between scientists and practitioners for reducing the substantive barriers between scientific knowledge and real world environmental problem solving.**

3 **Encourage more frequent co-production of knowledge and products so that purposeful interactions between scientists and practitioners can broaden knowledge while also addressing current and future environmental challenges.**

Background

The ideas contained in this handbook are derived from a project examining the use of climate research by public water utilities in three cities in the western United States: Denver Water in Colorado; Seattle Public Utilities in Washington; and Tucson Water in Arizona. We also sought to understand how the climate information needs of these water utilities helped shape the research agendas of the scientists who worked with them. Our main objective was to closely examine interactions between water resources professionals and climate researchers in these cities so that we could identify a set of lessons learned and best practices that make these types of collaborations successful. The project included more than 30 interviews in 2010 with water management professionals and research scientists who had previous and ongoing experience with science-management collaborations. We also convened a capstone workshop in 2011 to further develop and refine our findings. To help broaden our knowledge base, this final workshop included many of our initial project participants as well as experts who had not taken part in the project, but who have diverse experience with researcher-practitioner collaborations. This multi-method and engaged research approach allowed us to distill the shared knowledge and experiences of climate scientists and water managers into a set of practical lessons and suggestions that are likely applicable to individuals working in wide range of research and management fields.

Different Contexts, Similar Approaches

The cities in which this research was conducted—Denver, Seattle, and Tucson—represent a range of water resource management settings, which has direct bearing on the kinds of climate information each water utility needs, and therefore, on the ways that each utility interacts with climate researchers. For example, the climate in each of these cities differs dramatically, with Seattle receiving on average 37" of precipitation each year, while Denver receives less than half that (approximately 15"), and Tucson less than a third of that total (approximately 12"). It is no surprise, then, that the water supplies in each city are quite different. Seattle relies on two major watersheds to supply the vast majority of their municipal water. Denver gets most of its water from four major watersheds and is supplemented by supplies from three smaller watersheds. Tucson—in the Sonoran Desert and without access to perennial surface water—has historically depended on groundwater, but in recent years this has been heavily bolstered by the Central Arizona Project, a 336 mile-long canal that carries Colorado River water across some of the more arid parts of Arizona. The size of the populations served by these utilities also has bearing on water management strategies: Seattle Public Utilities and Denver Water are each providing water to just under 1.5 million people, whereas the Tucson Water service area population is just about half that, at approximately 700,000.

A significant reason Denver, Seattle, and Tucson were chosen as the study sites for this research was the existence of multi-year relationships between the water utilities in these cities and climate researchers affiliated with nearby universities. At the time we began our project, each of these university groups—the Climate Impacts Group (CIG) at the University of Washington, the Western Water Assessment (WWA) at the University of Colorado, and the Climate Assessment for the Southwest (CLIMAS) at the University of Arizona—was affiliated with the National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA) program. RISA is a network of regional partnerships between NOAA and universities whose primary

objective is to help expand and build the nation's capacity to prepare for and adapt to climate variability and change. Because the RISA teams have a somewhat unusual mission within academic science to develop knowledge that is directly useful for society, they have become known for their ability to work across boundaries that often exist between science and real-world decision making. Despite the fact that these utilities have quite different water management contexts and therefore have different climate-related concerns, the core similarity—concern about climate variability and/or climate change that led to a collaborative relationship with their local RISA team—provided us the opportunity to develop a set of insights about how scientists and practitioners interact to collaboratively address a common concern, in this case water management in the context of an increasingly uncertain future climate.

By assessing how these water utilities and their university research partners interacted we were able to develop a set of heuristics—which make up the majority of this handbook—to guide collaborations that span the science-management divide. We believe the lessons learned and best practices detailed here transcend not only the different water resources contexts we examined, but also are more broadly applicable to almost any collaboration that tries to integrate science and practice for the purpose of addressing a complex, socially relevant environmental problem. We have chosen to describe these as heuristics rather rules because rather than offering algorithms for successful collaboration, they provide sensible "rules of thumb" that are largely based on trial-and-error experiences for motivating, building, and sustaining researcher-practitioner collaborations.

Denver Water and Tree Rings

Denver Water is the largest urban water provider in Colorado, serving approximately 1.3 million customers and utilizing water from both the Colorado and South Platte river basins. In 2002, an extremely dry winter resulted in the lowest runoff recorded in many gauges throughout the state. Without a precedent in the instrumental record to guide planning, Denver Water managers were interested in knowing how often such low flows occurred over a longer period of time (gauge records are limited to 120 years in the best case). A collaboration with tree-ring scientists from the National Oceanic and Atmospheric Administration (NOAA) and University of Colorado helped answer this question and led to additional collaborative work that has been useful for water management. Ultimately, Denver Water used reconstructed flows from the Upper Colorado and South Platte river basins to run their water system model, which simulates streamflow, reservoir operations, and water supplies in both basins. One of the model outputs is total reservoir storage. Based on the 360-year tree-ring reconstructions, during the most challenging period of drought (the 1840s), Denver Water would have had sufficient water to serve customers, but with strict conservation measures enacted. The tree rings indicated that there were droughts in the not-too-distant past that were worse than historical gauge records and Denver Water's planning period. These events confirmed the need to maintain a water reserve and the importance of conservation measures during droughts. These collaborations took place over the course of about three years, with one or two face-to-face meetings a year, and many email messages. The outcomes of these interactions were productive for both the tree-ring scientists and water management professionals and have been helpful for developing other efforts between water utilities and researchers throughout the region.

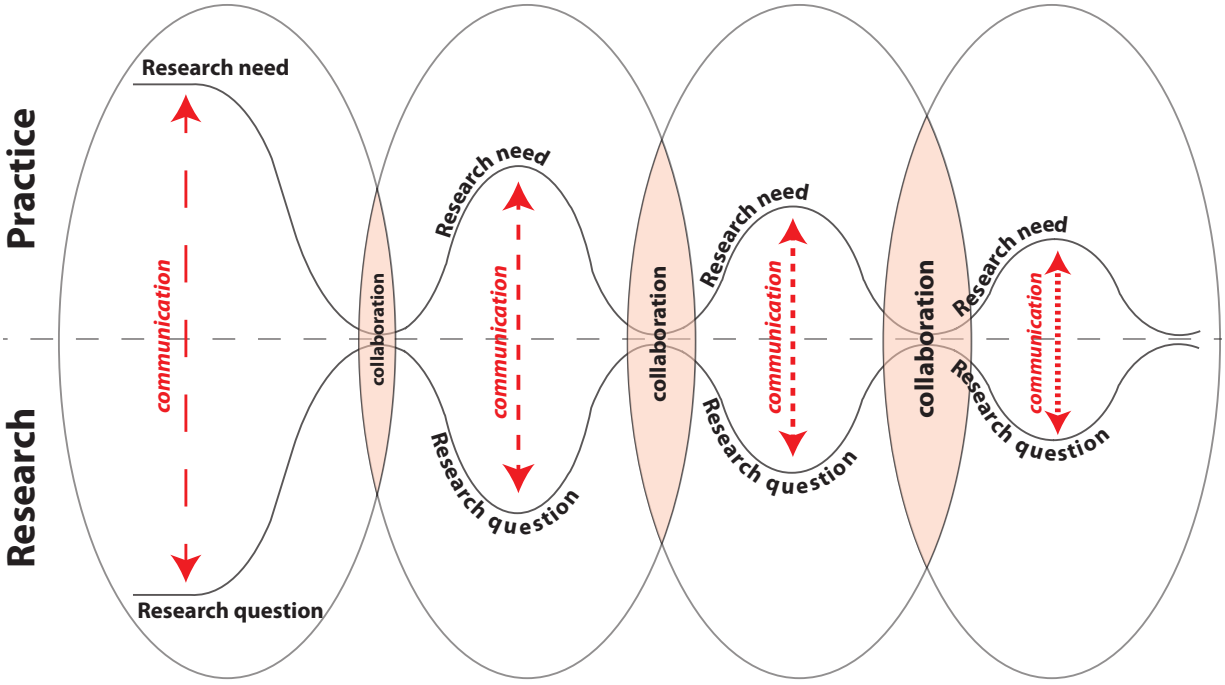
SCIENTIST-PRACTITIONER COLLABORATIONS

For practitioners who can use environmental research to help make decisions, and for scientists who want their research to be useful, the common ground that often brings these communities together is an especially complicated problem that neither community is capable of solving alone. For example, water managers in the United States are exceptionally good at evaluating a range of different risks—depending upon the nature of the water supply—to ensure that water reliably comes out of the tap. What if, however, that estimate of risk is dependent on science that is highly certain in terms of a long-term trend (e.g., historically unprecedented rising average temperatures), but highly uncertain in terms of season-specific forecasts? In this scenario, climate researchers may play a role in explaining the trend, potentially quantifying (or at least bounding) the uncertainty, or even, perhaps, exploring the range of vulnerabilities the utility may face. However, in practical terms, the climate scientists can provide only a sliver of the information that drives a decision about managing the risks associated with water availability. Neither the water management community nor the climate science community is well equipped solely to deal with the broad problem of water resources planning in the context of an unknown future climate, but given thoughtful and purposeful interactions, the two communities have the opportunity to positively influence each other so that both the management decision and the science will be improved.

While it is easy to imagine a scenario like the one above for fully collaborative, synergistic work between practitioners and researchers, the reality is that this process is substantially more complicated. One difficulty common in these types of interactions is that the motivations and expectations of the partners involved are not always fully compatible. Scientists are often driven to focus closely on isolated processes or complex interactions to better understand how a system (or a component of a system) works. Scientists strive for objective answers to vexing questions, albeit with a measure of uncertainty inherent in the answer. Practitioners, on the other hand, most often need to solve practical problems and look to science as one of many necessary pieces of information required to help inform their decisions. In the context of so-called "wicked problems," like large-scale environmental change, practitioners are often faced with options that involve complex trade-offs and value-based judgments, where scientific information must be considered alongside social, political, and economic constraints. Despite this challenge, we found abundant evidence that enough common ground exists for scientists and practitioners to work together to confront socially relevant environmental questions. The information provided in the remainder of this handbook explains the conditions under which this common ground can be created and fostered into meaningful collaborations that may produce the types of information required for meaningful integration of science and society.

Shrinking the Gap between Research and Practice

The question we were interested in exploring through this project was simply: how do collaborations between resource management professionals and scientists actually happen? Though each individual collaboration is unique, we were able to develop a generalized conceptual vision of how a common problem can be collaboratively addressed through consistent communication and purposeful, iterative interactions.



The figure above is an idealized diagram of the evolution of a collaborative partnership between resource management professionals and scientists that demonstrates a basic premise of this handbook: research can be more useful for practitioners if purposeful work is done by participants from both communities to shrink the gap between the way researchers conceptualize a problem and the ways that practitioners conceptualize the same problem. Each large oval represents a problem or challenge that is common to both the practitioner community and research community. The dashed line down the center of the figure is the conceptual boundary between research and practice. While the problem may be common (e.g., better understanding of long-term streamflow variability in a given river basin), the motivation for better understanding, and ways of framing and addressing it often are distinctly different for each community. The far left side of the figure illustrates early efforts to collaborate, where communication between the two communities may be infrequent and unfocused as suggested by the dashed red lines. For example, practitioners may know of a scientific study or read a peer-reviewed paper, but may have little or no personal contact with the researchers or may be unsure of how that information might be incorporated into their decision making process. Similarly, researchers may have a vague understanding of resource management agency or community concerns, but are not directly communicating with practitioners to fully understand the

specific issues. This process of parallel thinking about a common problem frequently means that the research being carried out (i.e., the knowledge supply) and the research result that may be needed by practitioners (i.e., the knowledge demand) are not necessarily compatible. Whatever brings about the initial contact between the two communities (e.g., workshops, conferences, professional networking, a motivated individual) these problems become more commonly defined as more communication and tangible collaborations take place (moving from left to right across the figure). In this idealized scenario the series of activities represented by the "collaboration" ovals initially may involve tasks focused on relationship-building and improving communication like co-convening a workshop to discuss the particular problem of interest (e.g., on the left side of the figure). As the participants from the practitioner and research communities communicate more, their mutual understanding of each other's professional language and culture grows, which should allow those collaborative activities to become more complex and result in more integrated problem solving. The net effect of the growth and evolution of these collaborative relationships is that the space shrinks between the research demand and the research supply and the collaborative space grows. It's important to note that while the space between research needs and research questions shrinks, it never disappears. Even in fully collaborative, long-term relationships between researchers and practitioners, these are distinct communities with different motivations and mandates. Shrinking the space between them is valuable; eliminating it is impossible and very likely to be undesirable in any case since each community serves a different function in society.

TEN HEURISTICS TO GUIDE SCIENTIST-PRACTITIONER COLLABORATIONS

The following ten heuristics provide guidance for those involved in, or hoping to become involved in, scientist-practitioner collaborations. The heuristics are organized in the order in which these issues may arise, from motivating a collaboration, through the processes of building and strengthening it, to sustaining the relationship for long-term partnerships. These ten heuristics represent a synthesis of the information we gathered during the interviews we conducted and at the project's capstone workshop. We have also included ideas for specific activities that may be helpful for motivating, building, and sustaining productive collaborations. Many of those specific suggestions were drawn from our project's final workshop where we explicitly solicited input from participants about activities they believe to be important and with which they have had success in their own work.

1 Preconditioning activities often set the stage for collaboration.

In examining how collaborative relationships got started, we found that casual interactions between practitioners and scientists, often with no intentionality or expectations for collaboration, can set the stage for a partnership. This phenomenon—which we call preconditioning—involves interactions that predispose a person or an organization to eventually seek out a collaboration. The exposure to new information or ideas (usually outside of one's direct area of expertise) can occur at a meeting or conference, through conversations in an informal setting, by reading newspaper or trade journal articles, or via word of mouth from colleagues. Although preconditioning is something that is not easily detected except in hindsight, it seems that the seeds of a collaboration can be planted without explicit intention through this kind of exposure. For example, a researcher may present information about climate change at a workshop for a practitioner community, and except for receiving a few questions, leaves the meeting wondering if anything he or she discussed has been useful. If preconditioning

happened, weeks, months, or even years later, a participant in that workshop might contact the researcher with questions and, if the timing and motivations align, a new collaborative project may be born. This lag is not surprising since after initial and even repeated exposure to new information, practitioners may need time to think about and discuss internally the relevance and utility of new ideas and information before making a decision to interact with a researcher. There are a number of other possible reasons that the contact may not be immediate, including the need to address other management priorities, political sensitivities, and resource availability. The inverse scenario, of course, may also be true: preconditioning can apply when a researcher is provided with an overview of management challenges and needs, but lacks a specific idea for how to contribute or interact in a useful way. More exposure to the inner workings of the particular practitioner community, additional perspectives on the context of decision making, and even discussions with other researchers often are needed before a researcher may feel she or he has something to offer.

Preconditioning is not a requirement, but it does provide an opportunity for breaching the boundaries between research and practice. For example, language barriers that arise because of professional jargon may slowly erode through preconditioning activities. Similarly, by exposing oneself to the culture of the potential partner, it may be easier to understand conceptual frameworks through which that community conceives of problems and works on solutions. Many researchers and practitioners have clearly benefited from interacting with only the most basic of motivations (e.g., "to see where the researchers are on problem X" or "to get a handle on what water managers do in situation Y"). Though hard to predict in advance, these seemingly insignificant interactions are often at the root of successful scientist-practitioner collaborations.

2 Information brokers are often central to successful collaborations.

An information broker is someone who has a broad understanding of scientific and practitioner perspectives and can act as a translator between the two. Information brokers must understand the management or policy context (e.g., objectives, legal constraints, timelines, spatial scales, and who makes what decisions) and have a solid grounding in the relevant scientific discipline(s). An effective information broker can place emerging research in the context of an existing body of knowledge, larger questions, management challenges, and management tools. In some cases brokers may be able to communicate sources of scientific uncertainty and thus better contexualize available research. They may have expertise in either social or physical sciences, but regardless of their backgrounds they possess the ability to think broadly across a variety of fields and applications. Information brokers may be based in academic institutions or in management agencies. We found that within each of the three collaborative environments we examined there were people who played the role of information brokers on the water utility *and* the university sides. By having skilled translators within the utilities as well as at the universities, there is little doubt that the flow of information between the organizations was made substantially more efficient than it otherwise would have been. While many agencies or organizations do not have the resources for a dedicated information broker, identifying a person within an organization who tends to think broadly and creatively across the science-practice spectrum often serves this function and can be helpful in motivating collaborations.

3 Building capacity to work across the science-practice boundary is critical. Successful collaborations to address complex environmental problems rely on the ability to work across the science-management divide. The capacity for this type of work is not inherently present in either the science or practitioner community, so it often must be intentionally cultivated. The ability of a scientist to recognize and articulate research questions relevant for decision making or for a practitioner to interpret and apply new data to a particular problem each require a specific level of insight that must be fostered since these skills are not necessarily internally valued in universities or agencies. By increasing not only personal capacity for this work, but also focusing on building institutional capacity to understand and value these types of collaborations, there is a greater chance of long-term success.

Aside from the preconditioning activities described above, providing cross-training opportunities (within an agency or across institutions) that expose individuals to the activities and daily responsibilities of peers across the science-management divide can also help increase the ability of individuals—and eventually organizations—to carry out cooperative work. Specifically, cross-training that is focused on skills and tools relevant to potential partners (e.g., for a scientist to learn the details of an operational model or a practitioner to become proficient in the approaches or methods of his or her research partner) can provide substantial capacity for long-term collaborations. For a more immersive experience, internships or externships can provide a deeper understanding of a collaborator's professional culture.

Information Brokers

Laurna Kaatz is a climate scientist for Denver Water's Planning Division. She has a background in physics and mathematics, including a master's degree in physics. Laurna's job is to coordinate and synthesize climate research and implement applicable results into water resource, drought, and long-range integrated resource planning for Denver Water. She is also responsible for operational and water rights analysis.

Laurna says that her "focus is on climate adaptation and translation. I work across the spectrum of science and policy, with climate modelers to policy makers. This includes helping researchers understand the needs and constraints of water resource managers and translating climate information into something practical for decision making."

Michael Crimmins is an associate professor in the department of soil, water, and environmental science and associate climate extension specialist at the University of Arizona. Mike provides climate science support to resource managers across Arizona by assessing information needs, synthesizing and transferring relevant research results, and conducting applied research projects. His extension work and research supports resource management across multiple sectors, including rangelands, forests/wildfire, and water resources.

Mike describes his job as "sort of like match making between science and decision making. I spend a lot of time talking to and listening to people who can benefit from our research. With that knowledge, I then have to help translate those needs into practical questions we can try to work on as scientists. That back and forth is fun and I think helps make the research we do more useful in the long run."

As collaborations begin to develop, other elements that increase capacity and the probability of a successful collaboration can expand to include activities such as interdisciplinary working groups, workshops, and peer-to-peer interactions. For example, on the academic side, there is a tight-knit community of researchers associated with NOAA's RISA network who frequently discuss common challenges and work cooperatively to pioneer new approaches to working across the science-practice divide. Similarly, the Water Utility Climate Alliance (WUCA) network provides a powerful peer organization for water utilities to focus on issues related to the production and use of new climate science. Information brokering is closely linked to capacity building, and as one increases, there is often a positive feedback with the other.

Motivating a Collaboration

Think creatively about workshops, conferences, or other events you can attend that may be be somewhat outside your area of expertise, but will provide a new audience with whom you can engage.

Know that it takes time to build the trust and relations that will set the stage for a meaningful and productive collaboration. Many small steps are often necessary in motivating a collaboration.

Be prepared to let go of preconceived notions of what information is important, what problems are urgent, or even the idea that you are right just because you are an expert in your field.

Anticipate when an event, news story, or other catalyst may set the stage for you to motivate a collaboration. In other words, be prepared for a rapid response when the opportunity for action presents itself.

4 Catalyzing events provide prime opportunities for collaboration.

Specific incidents—from climatic events, to political changes, to funding opportunities—may catalyze a latent collaboration. Sometimes the catalyzing event points out an obvious and specific practitioner need that can be addressed by scientists. For instance, in some western US river basins, the persistent drought in the early 2000s resulted in the lowest streamflow recorded in gauge records. That record low flow drove water managers to ask how often such a drought may have happened in the prehistoric past, the answer to which can be found in tree-ring data (see page 4). More often than not, however, these types of catalyzing events are subtle and require focused effort to become opportunities for collaboration. For example, it's not uncommon for changes in local, state, or national political leadership to open up a window for science-management collaborations that previously may have been perceived as futile. In the case of an election, a particularly thorny environmental issue may have been part of the campaign and therefore may now be the focus of attention in the scientific and practitioner communities, as well as in the general public. In the case of elections, there is also a chance that political change results in new or realigned funding priorities that create a compelling reason for researchers and practitioners to work together to tackle challenging environmental problems. The critical lesson is that taking advantage of these potential catalysts will often require an existing relationship and some level of capacity to carry out collaborative work. If those elements are in place, being proactive and paying attention to changing conditions—both physical and political—can yield important opportunities that may have otherwise gone unrealized.

A catalyst may also take the form of an incentive. The funding situation for environmental scientists is changing with a growing number of programs ranking proposals more

highly if they include interactions with those who have a stake in the research. It is up to researchers to take advantage of these incentives and build meaningful collaborations as opposed to pro forma statements about the societal relevance of their proposed work. In the context of climate change, resource managers and planners are also facing a new environment that at least tacitly encourages partnerships with researchers. For practitioners who have motivation or experience to utilize new information coming from researchers, they may have to overcome institutional momentum that thwarts the use of recent research. In that case, the goal for the practitioner may be to identify novel approaches to incentivize the use of scientific information within their organization by working within an established framework to find creative opportunities to demonstrate the value of the information.

5 **Successful collaboration requires mutual respect.** One theme that arose repeatedly in our interviews and during our final workshop was the idea that the trust that comes from genuine mutual respect is a critical foundation to successful collaborations. Specifically, being aware of any tendency to privilege one kind of knowledge (e.g., that which comes from science) over another (e.g., that which comes from practice) emerged as an important basis for the trust and respect that is needed. It is self evident that research and practitioner communities have their own professional cultures, so without some degree of understanding of a collaborator's insights, concerns, requirements, motivations, and definition of positive outcomes, it is difficult to effectively engage and interact. As is true for many of the heuristics contained in this handbook, mutual understanding and the respect that comes with it take time to develop. Both are fostered through some of the same activities that result in preconditioning and capacity building: attendance at workshops and conferences, casual conversations at breaks, visits to a counterpart's place of work, or any interactions that promote a genuine exchange of ideas. The value of these activities cannot be overstated since they are the bedrock upon which the trust and transparency that underlie relationships are built. There are, unfortunately, no shortcuts. Effective relationships based on mutual understanding and respect are sustained by consistent contact and communication with the same set of people.

6 **Personal and institutional flexibility allow for more collaborative opportunities.** Because there are often fundamental differences between the way a practitioner community and a research organization approach a problem, flexibility—both in terms of the institutions and the individuals involved—is vital if productive collaboration is the ultimate goal. One of the key lessons from our discussions with water resources professionals and researchers is the importance of finding ways to shrink the cultural divide between the two communities, which frequently means being willing to look past the norms of one's own professional culture. If scientists see how their research may be used in practice, and practitioners see how scientists approach a problem, the odds of successful collaboration should increase. While there is no recipe for bringing about this sort of awareness, our discussions yielded several suggestions for fostering personal and institutional flexibility.

INDIVIDUAL FLEXIBILITY

One direct path to increased personal flexibility is to be proactive in seeking out different perspectives on whatever problem is being addressed. A scientist trying to understand

how climate variability or change impacts existing or potential future surface water sources, for example, will probably find it worthwhile to reach out to water managers to gain some insight into how that community thinks about the same problem. Similarly, a water manager trying to understand what scientists are learning about future streamflow in their basin(s) will likely find it worth the effort to seek out researchers to understand how they are approaching the problem. Doing a little homework about what scientists/practitioners are currently thinking about can help establish a more common understanding. One goal for this type of activity is to recognize rigid structures that may exist within one's organization and consciously make an effort to look past them to find a different perspective on a problem. This level of personal flexibility initially may be uncomfortable, since it can require stepping outside of professional or disciplinary boundaries. However, with experience it becomes less awkward, especially once it yields some measure of new insight or even success in terms of a collaborative project.

INSTITUTIONAL FLEXIBILITY

Bringing about institutional flexibility is obviously more challenging than fostering personal flexibility, though it is possible. For example, a sabbatical that brings a researcher into a resource management setting, or a manager to a research setting, offers the opportunity for highly focused cross-institutional learning that can substantially kick-start a collaboration. While sabbaticals are a common characteristic of university faculty positions, they are not nearly as common outside of academia. However, a small percentage of private and public sector employers in the U.S. see the value of sabbaticals for both rejuvenating an employee as well as offering dedicated time to learn new skills or acquire new knowledge that can

Flexibility for Connecting Science and Decision Making

Kevin Werner
Western Region Climate Services Director, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Throughout his career Kevin Werner has held multiple positions within NOAA, including several years as a Service Coordination Hydrologist for the National Weather Service at the Colorado Basin River Forecast Center (CBRFC) in Salt Lake City, UT. At the CBRFC Kevin was charged with managing interactions between the CBRFC and a diverse group of stakeholders who use the information produced by CBRFC. In his current role as Western Region Climate Services Director, he has a more explicit mission to connect a very broad range of scientists and practitioners to help foster more responsive research and support multi-sector decision making. With degrees in Atmospheric Sciences and Math, Kevin is trained as a physical scientist, but his position requires a unique skill set that blends that scientific training with a keen eye for how people apply science to make decisions. As he advanced in his career, Kevin increasingly saw barriers to science application that went beyond the science itself. In 2007 this insight led him to return to school to pursue a Master of Public Administration and has recently completed coursework for a PhD in political science. The prime motivator for this move was to advance his understanding of the public sector and how science and forecasts can be applied more effectively. His PhD dissertation topic is focused on understanding and improving science applications in the real world of politics and complex decision contexts. By following this challenging career path, Kevin is demonstrating the kind of personal flexibility that is vital to working across the divide that commonly exists between research and applications.

ultimately improve the firm or agency. Hosting a university researcher on sabbatical can provide a powerful demonstration of the value of such efforts and—if such a collaboration is ultimately fruitful—may provide an incentive for adopting a sabbatical structure into the agency's culture.

Even without a full-blown sabbatical, seeking out ways that researchers and resource managers can become cross-trained on a common issue can help ease rigid, institutionalized thinking that may exist in both cultures. One institutional arrangement that we found to be highly successful is creating jobs that are structured to allow for ongoing cross-training. A fundamental reason that information brokers (described above) are able to maintain the role of boundary-spanners is that those positions are typically designed to allow for some measure of flexibility in job duties so that there is an opportunity to keep up with skills and knowledge that would otherwise be outside of a typical research or management position.

7 Having insight into institutional governance and norms is invaluable.

Perhaps the most basic barrier to successful collaboration between researchers and practitioners is the differing, and sometimes contradictory, institutional goals and mandates of the two groups. For a practitioner, being able to clearly communicate how a potential collaboration with a researcher fits into the organization's well-defined mandate (e.g., in the case of water utilities, to deliver clean, affordable water to customers) is not only necessary, it can be help identify a clear vision for at least one set of project goals. While this sounds easy enough, it may involve knowing much more than you otherwise might about your organization. There are several aspects about an organization that may be relevant to keep in mind, including:

- Political sensitivities within the institution (and being proactive about handling them).
- How information flows within the organization.
- How decisions actually get made.
- Where the decision points reside and the timeline of decision making.
- Technical issues that may make a collaboration unsuccessful from the start (e.g., capacity to handle types of data and information not typically used in operations).

Researchers must be similarly conscientious about the mandate of their university, department, or funder and be equally articulate about how the collaboration fits into those structures. On the surface it may appear that researcher-practitioner collaborations count little toward the major institutional rewards system for university faculty (i.e., tenure). However, a researcher may be able to successfully demonstrate why these collaborations support the mission of the university. For example, many public universities in the U.S. have some kind of mandate to serve the population of their home state. Researcher-practitioner collaborations can be framed as meeting this mandate while also making substantive contributions to one's particular department and discipline. It may be an added burden, but to the extent these types of collaborative projects fall outside the mainstream of academic life, the responsibility to articulate how they fit

in falls to the researcher, which means understanding one's own institutional structures well.

While it is never possible to be fully engrained in the culture and operations of your partner institution, it is worthwhile to gain as much insight as possible into how that organization works and how your collaboration fits into that structure. Each partner will have different motivations for the collaboration that may be strongly driven by various institutional mandates and incentives. Being aware of the mandates and incentives of partner institutions can help reduce the odds of miscommunication and conflict. For example, the majority of university-based researchers are driven for personal and institutional reasons to produce peer-reviewed literature, which entails specific criteria like carrying out research that is innovative and generates new knowledge rather than applying existing knowledge to a new problem. Those criteria may not be especially relevant or important to the practitioner community. A collaboration that recognizes these diverse motivations and works to ensure they do not interfere with the work is likely to be the strongest.

Building a Collaboration

Become an expert in how your organization works and be able to explain this to others. Also, think about how information moves through your organization and the best avenues to communicate new information to your coworkers and/or supervisors.

Take the time to talk about common terms and concepts used in your line of work at the beginning of the collaboration. Explain these to others and be sure to identify areas where the same term or idea (like "uncertainty") may have very different meanings depending on the context or person using it.

Discuss a set of ground rules about how to proceed with data creation, utilization, and dissemination that work with everyone's organizational needs and time frames. Also, talk about the responsibilities of all individuals involved, including students.

Consider creative methods of cross training, such as reading journals or publications by your partner organization, holding workshops to explain key functions or activities of your organization, or a flexible internship.

Finally, though it is convenient to think of individuals as representative of their institution or even the broad professional culture to which they belong (e.g., academia or resource management), it's critical to understand that at the heart of productive collaborations are well-developed relationships between individuals, each of whom brings specific perspectives to collaborative work. Though the professional culture from which your collaborator comes is extremely important for you to understand, knowing the particular role she/he plays in the organization as well as her/his personal motivations and experience are also critical. The importance of these individual relationships and specific perspectives becomes evident when someone leaves a job or even advances in her/his organization. In either case the odds are high that the nature of the collaboration will change, perhaps even necessitating a whole new round of relationship-building activities.

8 **Mutually agreed upon ground rules provide a framework for reducing conflict.** When it comes to collaborative science-management interactions, it is essential to discuss data production, dissemination of any results, deadlines, and ownership of data and results before work begins. Even when working relationships are friendly and well-established, different institutional demands, timeframes, and evaluation

procedures exist between practitioner and research communities. Public utilities or resource agencies, for example, have to consider the perceptions of customers and other government agencies, while scientists have an obligation to publicly disseminate and publish research in peer-reviewed journals in a timely manner. Graduate students may have specific timelines for submitting a thesis or dissertation related to some of the collaborative work, while practitioners may require information on shorter time scales to be useful. Furthermore, ownership of the data produced in a collaborative project may become less clear if portions of the analysis combine original research data with existing agency modeling or assessment techniques. Discussing these issues as a collaboration begins and clarifying how these potential conflicts will be handled can avoid predictable tensions as the work proceeds. Because it is inevitable that unforeseen circumstances will intervene over the life of a collaboration, it is wise to consider ways to periodically revisit these ground rules to ensure that all parties are happy with the way the project is evolving.

Why Establish Ground Rules?

One of the most contentious outcomes from a scientist/practitioner collaboration is the possibility of unfavorable results regarding the resilience or performance of a resource agency under environmental change. For example, a researcher may show that changes in precipitation will have significant impacts on the amount of water available for a city or region. While the researcher may see this as an important and timely finding that should be released to the wider public, he or she should understand that 1) the resource management agency may interpret the results differently when they factor in planning or other procedures they have in place to deal with these kinds of issues, and 2) how information is released to the public is of great importance for avoiding undue concern or misunderstandings about the situation. In this type of situation—which is not necessarily unusual—the seeds of potential conflict are embedded in the collaboration since many researchers perceive themselves working for the public interest by providing objective knowledge. The best way to prevent the conflict from manifesting is to spend time early in the collaboration openly discussing and agreeing upon how all research findings will be released to the public, whether sensitive or not.

Furthermore, it is important for the people involved in a collaboration to discuss the roles and responsibilities of all parties (including students) in the project, consider time constraints for both research publication and management applications, and discuss how and when the results of the work will be disseminated (e.g. press releases, agency reports, or journal articles). In the event that some information resulting from a specific study or assessment may be sensitive (e.g., assessments of climate change and water supplies), it is best if clear guidelines for how this information will be handled in the public and through publications is established before the onset of research. With projects that may garner media attention, it is especially important to have everyone agree on how media requests will be handled so that all the collaborators have similar expectations with regard to the flow of public information.

9 **Identifying and reconciling different perspectives can also reduce conflict.** Despite efforts to be flexible and to understand the mandates and culture of respective organizations, diversity in perspectives will remain since the mission and goals of research institutions and management organizations are different. It is critical to acknowledge and address these differences. For example, taking the time to decide

upon a common set of research and/or management goals and priorities can help ensure everyone understands the nature of the project for the duration of long (and often interrupted) collaborations. Another area of potential misunderstanding concerns the use of terms that have different meanings to scientists and practitioners. A term common in both research and practice is "uncertainty," though the meaning can be highly variable, even between academic disciplines. Other terms that commonly have several different meanings are "error," "bias," "mitigation," and "risk." The variability of meaning for these types of terms creates a lot of opportunity for miscommunication and conflict. Identifying such terms or concepts and clarifying how they will be used throughout a project can help limit potential problems.

Sustain Successful Collaborations

Build collaborative work into your career portfolio. For example, collaborations may be considered a "service" activity for academics and learning about environmental research may be seen as a valuable part of a manager's job description.

Think about joint communication or publishing opportunities to share the results of a collaboration with a diverse audience.

Set up ongoing communication opportunities through a listserv, open house, or social event.

Make a habit of attending conferences and workshops for scientists and stakeholders that your partners also attend.

10 Revisiting processes and outcomes nurtures long-term collaborations.

Once a collaboration has produced a result, it is tempting to end the process and go your separate ways. In academia, projects have finite lifetimes, and it is customary to move on when they are completed. Likewise, when practitioners have the information or product they need, it is natural to then devote time to other problems and issues. However, maintaining a more sustained collaboration may be worthwhile, particularly when considering the time, effort, relationship- and trust-building that went into the initial collaboration. Over the short term, revisiting the process and its result to make sure the final outcome was truly useful may ensure that something that appeared "good enough" becomes more precisely what was needed. Over the long term, an established collaborative relationship can enable both sides to take advantage of future windows of opportunity. These can prompt further collaborative efforts due to natural events (e.g., worsening drought conditions), new funding sources, a shift in public perception, or change in leadership. Maintaining ongoing relationships is especially pertinent in the context of climate change since both the research about it and decision making related to it are dynamic with new information and lines of inquiry revealing themselves over time.

One of the most important—yet often overlooked—aspects of sustaining a successful collaboration is building in feedback loops to maintain relationships and track the outcomes of interactions. It is relatively easy to periodically keep in touch with the people and organizations that were part of a collaboration and offers the benefit of gaining a long view by eventually seeing what outcomes resulted from the project months and years later. Maintaining contact often results in mutually fruitful future work.

Evaluating both the collaboration process and its outcome also provides the chance to identify what was more or less successful and can provide a guide for future collaborations. Evaluations can be done formally—for example by collecting data through interviews or surveys—or informally through conversation. While this part of the process is most often ignored, it can pay enormous dividends if the goal is to design repeatable processes or to build long term collaborative relationships. Considering how and why to do an evaluation when the project is initially planned will reduce the chance that benefits gained and lessons learned from the collaboration are lost. Because evaluation—even if done informally—requires an agreed upon set of metrics, the process of thinking through and implementing an evaluation of a collaborative project provides an opportunity to find common ground, which can be especially important at the outset of a project.

Conclusion

The heuristics above provide some guidance about how to motivate, build, and sustain science-management collaborations. We believe three fundamental concepts underpin these rules of thumb. First, because tackling complex environmental problems is by its nature difficult and may even seem impossible, a key indicator of successful collaboration is simply persistence. Most of the heuristics above point toward the need for sustained commitment to the common goal of solving a particularly difficult problem. That commitment almost always means leaving behind the relative intellectual comfort of ones training and professional culture and venturing out to explore how others see the problem, but it ultimately comes down to being determined to have a collaboration succeed and trying to solve a hard problem. Next, these heuristics suggest that processes that encourage consistent, purposeful, thoughtful, and iterative interaction across the science-management divide are the cornerstone of successful collaborations. A stand alone workshop to disseminate research results or gather stakeholder input may be a useful tool, but there is no question that it is insufficient for building lasting collaborations to solve large-scale environmental problems. There is simply no substitute for the time and concerted work on relationship building it takes to recognize and lower the barriers between scientists and practitioners. Finally, there is no denying that professional cultures differ among scientists and practitioners, but these differences offer the opportunity for diverse thinking and problem solving. Different perspectives must be recognized and properly acknowledged for collaborations to really blossom, but there is no reason why cultural dissimilarities should become impenetrable barriers. We found ample evidence that collaborations can flourish in the midst of diverse viewpoints provided there is an open environment that allows for common ground to be established. In return, these collaborations very often lead to intriguing new research questions and innovated solutions to real-world problems.

Appendix

KNOWLEDGE TO ACTION: CONNECTING CLIMATE SCIENCE & RESOURCE MANAGEMENT WORKSHOP

University of Arizona: Tucson, AZ

March 3-4, 2011

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