Collaborative Science-Stakeholder Engagement

An annotated reference guide for scientific engagement with natural-resource practitioners

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Introduction

This guide discusses collaboration among scientific disciplines and extending that collaboration to include participants outside of the academic world. It outlines various types of collaboration, both among researchers of diverse disciplines (single-, inter-, and multidisciplinary) and among researchers and stakeholders (transdisciplinary). It explores collaborations seeking to achieve different goals in natural-resource research and management (sustainability, climate change adaptive management, decision-making tool development, alternative futures exploration). It provides examples of stakeholder engagement in these contexts for the understanding and management of various natural resources.

Finally, this guide lists the lessons learned, necessary elements, and impacts from these case studies in three tables for quick reference when connecting science producers with science users.

This reference guide is intended as a resource for anyone interested in connecting science producers with science users. Engagement facilitators can use this guide to learn about the practice of scientist–stakeholder collaborations across disciplines and gain insights into the lessons learned through collaboration. The guide is also appropriate for agency practitioners and principal investigators researching the broader impacts of collaborative science, for example via grants from the National Science Foundation, NOAA, the national Sea Grant network, or others.

This guide summarizes literature from a broad swath of research with science-stakeholder engagement elements: 134 peer-reviewed articles from journals in the context of natural resource research, management, policy, and modeling. Several reviews have been published in the realm of stakeholder-driven modeling and alternative future development. Such articles do not provide the broad perspective we provide here, nor do they focus entirely on the science-stakeholder engagement process as does this guide.

We draw from recent literature and organize it in a way that we believe is helpful. However, the document is hardly exhaustive, and the topic is ever growing.

This reference is organized into the following three sections.

Scientific Collaboration Among Multiple Disciplines

Who is involved? (e.g., singular, multi-, inter-, or transdisciplinary)

What are their research goals? (e.g., sustainability, climate-change adaptive management, decision-making tool development, alternate futures exploration)

Stakeholder Engagement in Multiple Discipline Collaborations

Lessons Learned from Collaborative Science-Stakeholder Engagement

Scientific Collaboration Among Multiple Disciplines

To address challenging climate and natural-resource management problems, scientific research is moving toward studies that use a systems approach and integrate multiple disciplines to explore all parts of a system. Collaboration is useful in problem-solving situations, as individuals alone may fail to consider important elements of a decision that they later recognize as important from a group-generated list (Bond, Carlson, & Kenney, 2008). Including multiple perspectives is also important because each perspective alone may miss critical details (Huntington et al., 2002). Collaborative methods are necessary to research and manage shared natural resources (Johnson, 2011).

WHO IS INVOLVED?

Collaborations among academics are necessary to address real-world problems, because such issues do not confine themselves to one discipline (Dewulf et al., 2007). Collaborations are usually characterized by variations on terms that combine "single," "multi-," "inter-," and "trans-" with "-disciplinary."

Single disciplinary research is defined as collaborations among scientists within one discipline. Multidisciplinary research involves several disciplines in consultation on a project but does not necessarily require their integration or synthesis to achieve results (Schneider, 1997). Interdisciplinary research creates connections between those disciplines (Mader et al., 2013) to "work together to tackle problems whose solutions cannot be achieved by any single discipline" (Lemos & Morehouse, 2006).

Similar to interdisciplinary research, transdisciplinary research combines two or more disciplines to arrive at a more complete understanding of an issue. However, where interdisciplinary work benefits from an additive combination of the disciplines, transdisciplinary research extends collaboration one step further, placing a clear emphasis on "continuous interactions between scientists from different disciplines and different practice actors" (Lang et al., 2012) to promote mutual learning and systemic understanding of environmental issues (Mader et al., 2013). Transdisciplinary research is defined as "a reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge." It ensures that all critical knowledge is present in research, produces knowledge in a way that provides guidance to policy makers, and increases legitimacy and ownership of scientific results for users of science (Lang et al., 2012).

Although all approaches to collaborative research are beneficial to natural-resource research and management, transdisciplinary research provides an avenue through which researchers and science users can arrive at solutions to natural resource problems.

WHAT ARE THEIR RESEARCH GOALS?

Whether identified as transdisciplinary or not, collaborative scientific research projects can be categorized according to their research goals. Natural-resource, technology, and climate research fall within one or more of the following four categories: sustainability science, climate-change adaptive management, decision-making tool construction, and alternative future exploration.

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I. Sustainability Science

Sustainability science research is based on the ideas that environmental problems require cooperation and co-learning among natural and social scientists, professionals, and stakeholders to find solutions. Because resources do not respect organizational boundaries, research must span such boundaries. Sustainability science questions are driven by societal problems and seek to understand coupled social-ecological systems and address uncertainty (Kastenhofer et al., 2011). Swart et al. (2004, p. 138) synthesize a list of core sustainability science questions, including:

- How can the dynamic interactions between nature and society—including lags and inertia—be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
- How are long-term trends in environment and development, including natural-resource consumption and population, reshaping nature-society interactions in ways relevant to sustainability?
- What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of human livelihoods?
- What systems of incentive structures—including markets, rules, norms, and scientific information—can most effectively improve

social capacity to guide interactions between nature and society toward more-sustainable trajectories?

- How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?
- How can the future be scanned in a creative, rigorous, and policy-relevant manner that reflects the normative character of sustainability and incorporates different perspectives?

These studies seek not only to understand coupled human natural systems, but also to provide prognoses, address normativity, and formulate policy recommendations (Kastenhofer et al., 2011; Swart et al., 2004).

Universities can serve as a hub for facilitating information exchange and driving research toward collaboration with regional actors to solve society-driven challenges (Mader et al., 2013). For example, university researchers in Switzerland interviewed water managers to identify drivers and uncertainties within the system. Then, a group of experts—half academic scientists and half water managers—defined future scenarios that identified shared research priorities (Lienert et al., 2006). Other sustainability science studies are well reviewed in Lang et al. (2012), Swart et al. (2004), and Cash et al. (2003).

II. Collaborative Research on Adaptive Management to Climate Change

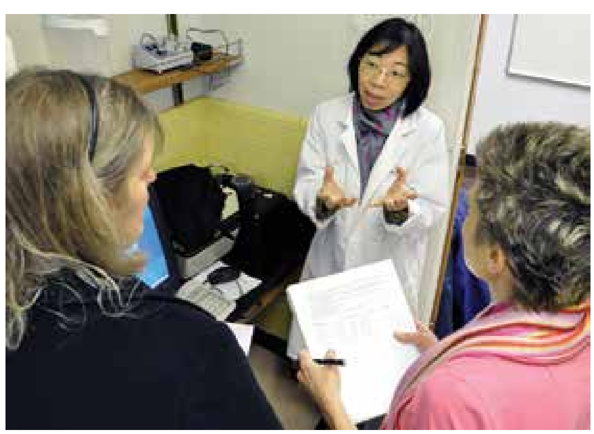
The second example of collaborative academic research is climate-change adaptive management. Research in this category is directed toward facilitating collaborative planning, and is thus more closely tied to policy (Mackenzie et al., 2012). Adaptive management is "a systematic process for continually improving management policies and practices by learning from the outcomes of implemented management strategies" (Pahl-wostl, 2007, p. 51).

Adaptive management is democratic and addresses uncertainty. It is based on the idea that different perceptions of a problem require participatory problem definition and resolution (Pahl-wostl et al., 2007), and thus requires a democratic space where a community can review and critique the research/adaptation process and improve its validity (Mackenzie et al., 2012).

Adaptive management attempts to address uncertainty, and thus is essential for managing resources in the face of climate change and its associated impacts (Lawler et al., 2010; Pahl-wostl et al., 2007). For this reason, adaptive-management research and strategies are often utilized for endangered-species management and risk assessments (ex. Gregory et al., 2013; Seney et al., 2013).

Additionally, adaptive management may investigate questions regarding the relationship between water management decisions, socioeconomic systems, and human behavior (Pahl-wostl et al., 2007) and what the impacts of planned actions may be (Lynam et al., 2010).

Climate change adaptive management is focused on learning, and is often playfully described as "learning to manage by managing to learn" (Pahl-



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wostl, 2007; Stubbs & Lemon, 2001). Learning can manifest in at least three ways. First, learning can mean acquiring facts or skills (Lynam et al., 2010), as when managers monitor research to adapt management plans as the situation shifts (Lawler et al., 2010). Learning can also manifest as drawing connections between subjects and the real world, as well as reinterpreting the facts to understand the world in a different way (Lynam et al., 2010). Adaptive management research achieves this second learning by requiring frequent interaction among multiple parties (Pahl-wostl et al., 2007). This is sometimes considered social learning and, when done in an adaptive management context, may contribute to increasing the adaptive capacity for different actors to manage resources effectively (Pahl-wostl, 2007; Pahl-wostl et al., 2007). A review of adaptive management in research collaboration can be found in Dilling and Lemos (2011).

III. Development of Decision-Making Tools

Another way in which collaborative researchers are addressing climate change and natural resource management questions is through the development of decision-making tools, often within a decision-making context. Here, the goal of research is to address an immediate need by creating a tool to inform an impending decision. The tool is tailored to the context and problem at hand. Often the decision-support tool is a model that integrates the various moving parts of the decision to be made. In decision-support tool construction, the focus is to make integrated management more tangible (Holzkämper et al., 2012) and more accessible (Holman et al., 2008). When effective, tool creation can lead to a user-friendly management tool, developed through facilitated stakeholder testing and feedback (Mackenzie et al., 2012), or it can lead to an accessible model, outputting information relevant to resource managers (Holzkämper et al., 2012).

Modeling tools have been built to support decisions in river-basin management in Germany (Lautenbach et al., 2009), water and agriculture management in Thailand (Becu et al., 2008), integrated water-catchment management (Holzkämper et al., 2012), and biodiversity and flood-risk management with climate change in the United Kingdom. In order for these decision-support tools

to be helpful, users of science must see them as credible, accurate, easy to understand, and appropriate to answer the question at hand (Holman et al., 2008).

IV. Exploring Alternatives with Decision-Making Tools

In many cases, the fourth category of collaborative research is conducted within decision-making tools to explore alternative futures, or makes use of modeling tools to evaluate scenarios. Research exploring alternative futures uses modeling and scenario building as a discussion driver and a tool for visualizing potential futures. A key component of exploring alternative futures is developing multiple scenarios for comparison and assessment of the magnitude of future uncertainty (Santelmann et al., 2001). The International Panel on Climate Change defines a scenario as "a coherent, internally consistent and plausible description of a possible future state of the world…each scenario is one alternative image of how the future can unfold" (IPCC, 2008). Exploring alternative futures is exploring alternative scenarios of the future according to imagined climate and climate-influenced environmental conditions (Snover et al., 2013). The goal of adaptive management research is to strengthen capacity to respond to changes when the future is uncertain. Alternative futures analysis, through comparing scenarios of the future, aims to bracket that future uncertainty. It is important to remember that the scenarios represent "neither predictions nor forecasts" (Swart et al., 2004, p. 139) and are simply imagined futures.

Although hypothetical, scenarios should be physically and politically plausible and reflect stakeholder values, assumptions, and visions of the future (Baker et al., 2004) and serve as the basis for visualizing potential futures (Baker et al., 2004; Hulse & Gregory, 2001; Mahmoud et al., 2009; Santelmann et al., 2001; Sheppard et al., 2011). The alternative futures approach has been used in the context of restoring riparian areas (Hulse & Gregory, 2001) in species impacts assessments, and in agricultural land-use decision-making (Santelmann et al., 2001). It has been used to answer sustainability-science questions (Santelmann et al., 2001; Swart et al., 2004) and to describe potential outcomes of a range of possible policy options (Baker et al., 2004). In this way, various management strategies can be explored, and risk assessed, given different climate and policy conditions (Snover et al., 2013). Finally, the benefit of exploring several scenarios with different system factors leads a research team to understand compounding effects of policy and climate conditions beyond a single variable-sensitivity analysis. Mahmoud et al. (2009) review the process for developing scenarios, and Swart et al. (2004) review alternative futures through scenario development to inform sustainability science.

Natural-resource, technology, and climate-collaborative research can be categorized according to the goals each intends to achieve. Sustainability science seeks to understand coupled social-ecological systems to solve problems in sustainability. Climate-change adaptive management focuses on learning as much as possible about coupled social-ecological systems to modify management plans according to the current situation. Decision-making tool research works to develop tools that inform a decision immediately at hand. Additionally, developed tools can be used to explore alternative futures. Evaluating alternative scenarios informs less-immediate management and policy decisions by offering possible future impacts on coupled social-ecological systems of potential natural and political conditions. Each of the above research goals has a place in multi-, inter-, and transdisciplinary collaboration among academic researchers to address the challenging problems of climate change and natural-resource management.

Stakeholder Engagement in Multiple Discipline Collaborations

To extend scientific production and results beyond academia, research teams are reaching out to and engaging with stakeholders. Just as the collaboration types outlined above view and address natural resource challenges from different angles, research projects within them can engage stakeholders in diverse ways. Stakeholder engagement is one way to transform interdisciplinary research into transdisciplinary knowledge and to broaden research impacts. Through stakeholder engagement, research teams can produce societally relevant and understandable results. Stakeholder engagement involves working with groups of overlapping geographic or subject interests or identities to exchange or create knowledge to improve science and influence societal practices (Mackenzie et al., 2012).

Research is more useful when it is produced by collaborations with those who are most likely to use it (Johnson, 2011). The National Research Council calls for direct engagement between scientists and users of science to achieve effective climate-change decision-making (National Research Council, 2006). Dilling & Lemos (2011) found in their review of multiple research efforts that usable science is a function of both the context in which it will be used and the process followed to produce the science. Nearly all cases that produced usable science followed an iterative process between scientists and science users. This section discusses some cases drawn from the research categories explored above to demonstrate how stakeholder engagement has benefited research products and impacts.

In sustainability science, stakeholder engagement is employed to address the key challenge of integration (Swart et al., 2004). In a study where researchers in Switzerland reached out to water managers to identify research priorities, process participants gained a better understanding of each other and benefited from sharing information. Researchers reported that they shifted from technological-support focus to decision-support focus, and stakeholders discovered the potential for technological innovation (Lienert et al., 2006). A university in the Netherlands facilitated a multi-stakeholder regional-planning project for sustainability research in which students worked with stakeholders to first form a diverse network and then participated together in regional policy development and implementation (Sol et al., 2013). Science is influential in decision-making when it is created together with stakeholders and not for them (Fuller, 2011). Stakeholder engagement in sustainability science results in knowledge sharing, increased understanding, re-framing of focuses, and network formation.

In climate-change adaptive management, involving stakeholders from the beginning to help generate research priorities and metrics can lead to usable science (Dilling & Lemos, 2011). A collaborative planning process to adapt management practices to future climate change in the American Southwest led to knowledge co-production (Cross et al., 2013). In another example, successful management of air quality in the United Kingdom required the formation of a network of all actors responsible for air management. This network was driven by a shared vision of adaptive management despite

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diverse interests and responsibilities to their respective employers. The result was a cohesive core group of participants sharing information "with loose affiliations which seemed likely to take on greater importance in the future" (Stubbs & Lemon, 2001, p. 330).

Participation in a climate- and forest-management study in Oregon led managers to think more scientifically and to better understand, undertake, and communicate experimental results. Scientists, in turn, learned to connect their scientific questions to relevant problems and focus on applying findings (Halofsky et al., 2011). By allowing lay knowledge to help devise policies that are practical (Juntti et al., 2009), stakeholder engagement increases research legitimacy (Lemos & Morehouse, 2006). Climate-change adaptive management studies show that engaging with stakeholders produces more relevant science, co-produces knowledge, and leads participants to learn about each other and the subject. Finally, results are perceived to be more legitimate and practical for implementation.

In decision-support tool research and development, stakeholders are involved because they will be making the decisions that the tool informs. It is important that the tool be developed to provide information that decision makers need. Participation, then, "should include experts in the various domains of science and management as well as those responsible for or affected by the decisions to be made" (Holzkämper et al., 2012, p. 117).

Developing a decision-support tool for water and agricultural land management in Thailand led to the model representing a shared reality and greater understanding of the model, and fostered a dialogue among conflicting groups and prepared them for future collective decision-making (Becu et al., 2008). A water-quality management project in Australia that incorporated managerial knowledge into a decision-making tool improved credibility for the tool and contributed to learning (Lynam et al., 2010). Stakeholder engagement in decision-support tool research also facilitates discussion and inspires future research questions (Halofsky et al., 2011).

Studies that explore alternative futures also benefit from engaging with stakeholders. In fact, in climate science it is recommended that scientists interact with decision makers throughout the process of choosing scenarios for impact assessments (Snover et al., 2013). Including stakeholders in scenario development is useful for science outreach and education as well as planning (Holzkämper et al., 2012; Mahmoud et al., 2009; Sheppard et al., 2011). One alternative-futures study on stream conditions and wildlife habitat in Oregon found that by engaging with stakeholders, they were able to incorporate local knowledge, increase stakeholder understanding, and promote a sentiment of shared ownership in the results leading to the tool and the study results being used (Baker et al., 2004).

The same study found that they could build consensus through stakeholder engagement by providing a space to clarify differences in opinion, visualize the magnitude and location of changes required to achieve a proposed future, present system-level implications of proposed plans and assess those implications together (Baker et al., 2004). Stakeholders can inform the research process of the local drivers and policy climate, and help to select more plausible scenarios (Snover et al., 2013). Co-learning in this way creates a context for diverse groups to meet and work together and can be one of the most important outcomes. This process of gaining a common understanding through co-learning reduces conflict and can be more important than the resulting model (Voinov and Bosquet, 2010). It can be important and beneficial to continuously involve stakeholders in scenario development and alternative futures exploration studies (Mahmoud et al., 2009).

Stakeholder engagement is one way to achieve collaborative research broader impacts, but it is also a way to improve science itself. Engaging with people of diverse backgrounds improves practices in science and education (Jensen et al., 2008). Scientists may also benefit individually, as those who actively disseminate their results perform better academically (Jensen et al., 2008). Thus, community engagement can improve both decision-making in a management community and the quality of the research conducted (Bonney et al., 2009). There are many benefits of stakeholder engagement to scientific intellectual merit and broader impacts.

Lessons Learned from Collaborative Science-Stakeholder Engagement

We can glean lessons learned and necessary elements for successful science-stakeholder engagement from the case studies explored above. We can also look to their example as evidence for the impacts science-stakeholder engagement processes can have on research and its outcomes.

Case studies offer insight from their lessons learned on the process and organizational mindset with which a person should enter into science-stakeholder collaborations. These lessons learned are listed in the table below and include establishing clear roles and responsibilities for all participants, allocating resources well, and accepting external expertise as credible. The overall theme in these lessons learned is that science-stakeholder collaboration is a new and evolving method of addressing natural resource problems, so it must be approached with new perspectives on research and adequate resources to support the developing method.

Lessons learned	Source
Clear roles and responsibilities	Ferguson, 2015; Lang et al., 2012; Mackenzie et al., 2012; Matso & Becker, 2014; Voinov & Bousquet, 2010
Allocate resources well	Becu, Neef, Schreinemachers, & Sangkapitux, 2008; Ferguson, 2015; Kearney, Berkes, Charles & Wiber, 2007; Kloprogge & van der Sluijs, 2006; Lemos & Morehouse, 2006; Mackenzie et al., 2012; Matso & Becker, 2014
Be sensitive to stakeholder needs	Kloprogge & van der Sluijs, 2006; Lang et al., 2012; Lemos & Morehouse, 2006; Mackenzie et al., 2012
Consider relationship to research funders	Mackenzie et al., 2012
Focus on process rather than product	Dilling & Lemos, 2011; Kearney et al., 2007; Lautenbach, Berlekamp, Graf, Seppelt, & Matthies, 2009; Voinov & Bousquet, 2010
Accept uncertainty	Holzkämper, Kumar, Surridge, Paetzold, & Lerner, 2012; Voinov & Bousquet, 2010
Accept external expertise as credible	Ferguson, 2015; Mackenzie et al., 2012
Engage early	Ferguson, 2015; Holman et al., 2008; Matso & Becker, 2014
Integrate qualitative and quantitative knowledge	Cross, McCarthy, Garfin, Gori, & Enquist, 2013
Manage both stakeholder engagement and interdisciplinary portions	Daniell et al., 2010; Ferguson, 2015; Huntington et al., 2002; Lemos & Morehouse, 2006; Matso & Becker, 2014
Produce non-normative publications	Leydesdorff & Ward, 2005
Make use of existing relationships	Ferguson, 2015; Huntington et al., 2002

A review of case studies also reveals necessary elements for successful science-stakeholder collaborations. The table below displays these elements in list form paired with their literary sources. Of course, this list will grow as our understanding of collaborative research processes increases. Necessary elements include having a committed team and engaging in a transparent and iterative process through frequent interactions.

Necessary elements	Source
Strong leadership	Lemos & Morehouse, 2006; Manring, 2014; Sol et al., 2013
Collaborative research team	Dilling & Lemos, 2011; Kearney et al., 2007; Lang et al., 2012; Lemos & Morehouse, 2006; Manring, 2014
Mutual trust	Kloprogge & van der Sluijs, 2006; Lemos & Morehouse, 2006; Mackenzie et al., 2012; Mader et al., 2013; Sol et al., 2013; Voinov & Bousquet, 2010
Commitment to project	Kearney et al., 2007; Sol et al., 2013
Transparency	Johnson, 2011; Lang et al., 2012; Voinov & Bousquet, 2010
Iterativity	Dilling & Lemos, 2011; Ferguson, 2015; Halofsky et al., 2011; Holman et al., 2008; Lang et al., 2012; Swart, Raskin, & Robinson, 2004; Voinov & Bousquet, 2010
Untraditional metrics of success	Mackenzie et al., 2012; Voinov & Bousquet, 2010
Mid-size, diverse group	Bartels et al., 2013; Swart et al., 2004; Voinov & Bousquet, 2010
Shared reframing of issue/plan/goal	Dewulf, François, Pahl-wostl, & Taillieu, 2007; Fuller, 2011; Halofsky et al., 2011; Kearney et al., 2007; Lang et al., 2012; Lautenbach et al., 2009; Lemos & Morehouse, 2006; Mackenzie et al., 2012; Matso & Becker, 2014; Sol et al., 2013
Facilitators/Boundary organizations	Cash et al., 2003; Dilling & Lemos, 2011; Ferguson, 2015; Johnson, 2011; Kearney et al., 2007; Mackenzie et al., 2012; Robinson & Wallington, 2012; Sol et al., 2013
Visualizations	Sheppard et al., 2011
Frequent interaction	Johnson, 2011; Kloprogge & van der Sluijs, 2006; Lemos & Morehouse, 2006; Mader et al., 2013
Strong research infrastructure and networks	Ferguson, 2015

Lessons learned and necessary elements are important to take from previous case studies of science-stakeholder collaboration. However, it is also important to look to case studies as examples of the impact science-stakeholder collaboration can have on research and its results. The table below lists some impacts documented by case studies of science-stakeholder collaboration. These include improved relationships among researchers and stakeholders, increased credibility and legitimacy for the research results, and more wholly informed results.

Impacts	Source
Learn from one another	Bartels et al., 2013; Becu et al., 2008; Ferguson, 2015; Huntington et al., 2002; Lienert, Monstadt, & Truffer, 2006; Tim Lynam, Drewry, Higham, & Mitchell, 2010; Manring, 2014; Stubbs & Lemon, 2001
Improve understanding	Becu et al., 2008; Cross, McCarthy, Garfin, Gori, & Enquist, 2013; Ferguson, 2015; Lienert et al., 2006
Visualize future	Becu et al., 2008; Lienert et al., 2006
Increased credibility	Baker et al., 2004; Cash et al., 2003; Holman et al., 2008; Holzkämper et al., 2012; Tim Lynam et al., 2010
Incorporate managerial knowledge (accurate, accessible, appropriate research)	Baker et al., 2004; Holman et al., 2008; Tim Lynam et al., 2010
Network building	Becu et al., 2008; Cross et al., 2013; Ferguson, 2015; Holzkämper et al., 2012; Leydesdorff & Ward, 2005; Manring, 2014; Stubbs & Lemon, 2001
Increase stakeholder self-efficacy	Baker et al., 2004; Sheppard et al., 2011
Future research emerges	Bartels et al., 2013; Becu et al., 2008; Halofsky et al., 2011
Diverse dialogue	Becu et al., 2008; Cross et al., 2013; Ferguson, 2015; Halofsky et al., 2011; Huntington et al., 2002
Increased legitimacy	Cash et al., 2003; Ferguson, 2015; Fuller, 2011
Increased saliency	Cash et al., 2003

Conclusion

This guide outlined various types of collaboration, both among researchers of diverse disciplines (single-, inter-, and multidisciplinary) and among researchers and stakeholders (transdisciplinary). It explored collaborations seeking to achieve different goals in natural-resource research and management (sustainability, climate change adaptive management, decision-making tool development, alternative futures exploration). It provided examples of stakeholder engagement in these contexts for the understanding and management of various natural resources. Finally, this guide listed the lessons learned, necessary elements, and impacts from these case studies in three tables for quick reference when connecting science producers with science users.

The case studies demonstrated that a deliberate collaborative scientist-stakeholder engagement process of co-learning can increase accountability and encourage more integrative progress and societal relevance on complex natural-resource issues. Many of these case studies cited that developing research infrastructure and network through engagement processes could be an even more important outcome than the resulting model or method. Many case studies indicated that it is valuable for diverse stakeholders to meet in a neutral space such as a research process to inquire, co-learn, and come to a common understanding.

There is much to be said of the beneficial impacts of science-stakeholder collaborations; however, these benefits are contingent on the process itself. The case studies discussed above share that, in order to be successful, science-stakeholder engagement must possess strong leadership, a cohesive team, trust, transparency, iterativity, and diversity. Teams must be clear on roles and responsibilities and shift their thinking on acceptable metrics, expertise, and levels of uncertainty. Finally, they must dedicate adequate resources—time, people, and funds—to support the process. With these elements, a team is better equipped to achieve the outcomes of previous case studies in science-stakeholder engagement and more.

We invite you to explore the use of science-stakeholder collaborations in your own research, management, and policy regarding natural resources, building upon the examples and lessons provided in this guide.

You’re Invited!

Who: A committed team of researchers with strong leadership and diverse stakeholders

What: A transparent, iterative, and collaborative research process

When: Your current and next research project

What to bring: An open mind to meet people with different or similar expertise and perspectives, explore processes and share any resources you have available to you

Why: Improved understanding and network; increased legitimacy, saliency, and credibility; enriching dialogue; develop future collaborations

Connecting those who produce science with those who need to use science in management decisions and planning is a critically important task. There is a growing body of literature and experience to help improve efforts to integrate science and management to address issues of sustainability, climate change, and development. We have listed here some of the literature relevant to stakeholder engagement and the effectiveness of various approaches and practices, to help those engaged in this type of research to benefit from the experience and lessons learned in other studies.

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