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A word to the wise: Advice for scientists engaged in collaborative adaptive management

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Abstract

Collaborative adaptive management (CAM) is a process for making decisions about the environment in the face of uncertainty and conflict. Scientists have a central role to play in these decisions. However, while scientists are well-trained to reduce uncertainty by discovering new knowledge, most lack experience with the means to mitigate conflict in contested situations. To address this gap, we drew from our efforts coordinating a large CAM effort, the Sierra Nevada Adaptive Management Project, to offer advice to our fellow environmental scientists. Key challenges posed by CAM include the confusion caused by multiple institutional cultures, the need to provide information at management-relevant scales, frequent turn-over in participants, fluctuations in enthusiasm among key constituencies, and diverse definitions of success among partners. Effective strategies included a dedication to consistency, a commitment to transparency, the willingness to communicate frequently via multiple forums, and the capacity for flexibility. CAM represents a promising, new model for scientific engagement with the public. Learning the lessons of effective collaboration in environmental management is an essential task to achieve the shared goal of a sustainable future.

Introduction

Natural resource management in this era of global change is a complex task rife with uncertainty (Williams and Brown 2014). Nonetheless, decisions must be made. Too often, they are made without a sufficient scientific basis (Scarlett 2013; NAS 2016).

Adaptive management aims to fill this knowledge deficit by treating management actions as an experiment and then using the empirical results to improve future decisions (Walters and Holling 1990; Susskind et al. 2012). The site- and time-contingent learning provided by adaptive management is essential if natural resource managers are to make informed decisions under changing environmental conditions. Despite the promise of adaptive management, implementation of long-term, landscape-scale adaptive management projects is rare (Bormann et al. 2007; Allen and Gunderson 2011; Greig et al. 2013).

Rarer still are projects that also include collaboration between multiple agencies, public stakeholders, and university researchers. Because management of social-ecological systems can involve contested goals and decisions, land management agencies are increasingly required to consider stakeholder input (Reed 2008). However, merely collecting stakeholder opinion often does not reduce conflict so agencies have turned to the collaborative process as a means of achieving greater engagement and, ideally, reaching consensus through shared learning and relationship-building (Reed 2008). For example, the 2009 Forest Landscape Restoration Act is one of several recent federal statues to specifically call for collaboration in the management of National Forest System lands (Cheng and Sturtevant 2012; Schultz et al. 2012; Butler et al.

2015). Collaboration can encompass many related processes (Conley and Moote 2003; Reed 2008; Susskind et al. 2012): engaging stakeholders in natural resources management; incorporating local knowledge; increasing mutual learning; reducing conflict; building relationships; and maximizing the diversity of perceptions. Collectively the hope is that these collaborative efforts will lead to more effective management with less strife.

Efforts that incorporate elements of both adaptive management and collaboration are often referred to as collaborative adaptive management or CAM (Susskind et al. 2012; Beratan 2014). CAM incorporates two recommendations for improved governance of natural resources: the inclusion of multiple stakeholders in the decision-making process and the treatment of management actions as experiments (Beratan 2014; Butler et al. 2015). Yet delivering on the potential of CAM is demanding given the inherent complexity of ecosystem dynamics, the potential for conflict among participants, and the costs in terms of time and money (Scarlett 2013; Williams and Brown 2014; NAS 2016). Despite a great deal of academic interest (e.g., Galat and Berkley 2014), there is relatively little guidance on how to overcome the barriers to CAM (Beratan 2014). In particular, the perspective of environmental scientists with experience leading a CAM project is largely absent.

For the past eight years (May 2007 to December 2015), we led the Sierra Nevada Adaptive Management Project (SNAMP; Hopkinson and Battles 2015). The goal of SNAMP was to learn how to use an adaptive management and monitoring system to understand ecosystem behavior, incorporate stakeholder participation, and inform the implementation of adaptive management for National Forest lands in the Sierra Nevada of California. Our task in terms of project management and integration was to coordinate a multi-disciplinary research effort that investigated the effects of forest fuel treatments on fire behavior, forest health, sensitive wildlife species, water balance, and water quality at two sites in the Sierra Nevada conifer forest, while simultaneously facilitating collaboration between all SNAMP participants and studying the collaborative process itself. While it is too early to evaluate the impact of SNAMP on the management of National Forests, it is appropriate to mine our experience for insight regarding the implementation of CAM. Such practical advice based on an empirical example of adaptive management is a priority research need (Fabricius and Cundill 2014). Therefore in this paper, we describe the challenges we encountered and the strategies we applied to complete SNAMP, with the hope that these insights will prove useful for researchers who are planning and implementing CAM projects of similar scope and scale.

Background/Methods

SNAMP was established to cope with the controversy and uncertainty over the plan for forest management in the Sierra Nevada described in the United States Forest Service's 2004 Sierra Nevada Forest Plan Amendment (USFS 2004). The Amendment established the legal framework for the management of over 46,000 km^2 of National Forests lands. Nearly a century of fire suppression in the Sierra Nevada has had the unintended consequence of placing millions of hectares of forest at risk of catastrophic fire (van Wagtendonk 1998; North et al. 2015). This regional assessment of fire hazard and fuel loads was reflected in the Amendment (USFS 2004), where modifying wildland fire behavior was a management priority. The plan called for the strategic application of fuel management at the landscape level (10s of km^2). Despite the sound conceptual underpinning of the proposed fuel treatments (Finney 2001), stakeholders expressed concern. More than 6,200 appeals to the amendment were filed (USFS 2004). The major issue was how the focus on wildfire mitigation would impact other forest resources such as wildlife habitat and water quality. In a novel effort to find a way forward that avoided typical patterns of conflict, state and federal resource agencies (Table 1) signed a Memorandum of Understanding (MOU 2015) that asked University of California (UC) scientists to serve as a “neutral third party” of experts who would assess the impacts of fuel treatments on the forest, while also engaging public stakeholders meaningfully in the CAM process (Rodrigues 2008). The two key roles for the UC science team were to inform management with relevant science and to provide an impartial forum for discussion.

SNAMP applied active adaptive management (sensu Gregory et al. 2006) to test the efficacy of proposed landscape-level wildfire mitigation treatments and to quantify the impacts of this treatment on related forest resources (Bales et al. 2015). The scale of the effort as described in the 2004 Sierra Nevada Forest Plan Amendment (USFS 2004) needed to consider “broad landscapes” called firesheds. In concept, firesheds are analogous to watersheds but are topographic units delineated based on the behavior of a problem fire – a fire that has the greatest negative potential impact given local topography, weather, and fire history. The size of firesheds can vary, but they need to be sufficiently large to assess the effectiveness of fuel treatments (Bahro et al. 2007). Logistics limited SNAMP to two sites in the Sierra Nevada, one in the northern part of the range and one in the southern. To isolate effects of the forest management operations, we used a before-after-control-impact design. At each site, we defined a control fireshed (no management action) adjacent to the planned treatment area. Measurements were made before and after management in both the treatment and control firesheds (Hopkinson and Battles 2015).

SNAMP involved eight state and federal agencies (Table 1). Funding (~$12.5M in direct support) came from multiple agencies, with funding renewed (and on more than one occasion, almost not renewed) annually. The UC science team comprised twelve principal investigators from five institutions and their research staffs. Furthermore, SNAMP was committed to full public engagement so numerous public stakeholders formed an integral part of project (Table 1). Multiple groups meant multiple institutional cultures, and these different cultures permeated every aspect of the project, from where the next year's funding was coming from, to days of the week available for meetings, to what words could or could not appear in reports.

We use SNAMP as a case study. Our results are based on our experience as the science team members responsible for project management and integration. The challenges and strategies described below summarize our analyses of the problems and the solutions we ultimately applied. Our efforts were supported by extensive documentation of meetings both among the UC science team, our agency partners, and with the public (Rodrigues 2008; Kelly et al. 2012). These resources, all but the UC science team notes, are archived and available on the SNAMP website (http://snamp.cnr.berkeley.edu/).

Challenges

Any project the size and complexity of SNAMP presents a host of organizational and logistical challenges. We focused on the issues pertinent to an adaptive management project committed to engaging the public. The myriad challenges encountered were organized into five categories.

1) Integrating multiple disciplines and institutions, each with its own traditions and norms.

Achieving integration proved difficult both within and between the three primary groups (UC scientists, agency staff, and public stakeholders). The SNAMP research team included hydrologists, wildlife biologists, forest ecologists, remote sensing scientists, and social scientists, each using different methods, employing specialist vocabularies, and working at different spatial and temporal scales. The agencies were federal or state, land management or regulatory agencies, with varied responsibilities, goals, and funding cycles. Public stakeholders and interest groups had diverse agendas, expectations, and norms too. This mash-up of cultures caused confusion, misunderstandings, communication crises, and hurt feelings that all had to be managed for the project to succeed. An additional constraint was that some SNAMP participants had previous and even ongoing contentious relationships with one another, which increased the difficulty of fostering a common purpose and plan (although see Laws et al. 2014 for the positive value of conflict in CAM). Interdisciplinary and interagency projects are not unusual (e.g., Greig et al. 2013), but coping with the problems caused by clashing norms and goals was major task for SNAMP that should not be underestimated or overlooked.

2) Reconciling research and management scales.

The trend over past several decades has been to manage natural resources at increasingly large spatial scales: from the forest stand to the small watershed to the landscape (Urban 2000; North 2012; NAS 2016; Scarlett and McKinney 2016). SNAMP's response variables were assessed at different spatial scales: water in the headwater catchment (~100 ha); fire behavior and forest ecosystem health in the fireshed (~10,000 ha); wildlife populations in much larger areas appropriate to the species under study (e.g., the SNAMP study area for the Pacific fisher, *Pekania pennant*, was 130,000 ha). The raw results from the research did not directly translate to management-relevant scales (Bormann et al. 2007). Reconciling the mismatch was essential to avoid the oft-noted failure of university scientists to deliver management-relevant information (Rogers 1998).

*3) Maintaining support despite turn-over in leadership***.**

During SNAMP, there were dozens of people closely involved in the project: federal and state agency staff at many levels; academics, their students, and other assistants; stakeholders representing industry groups, environmental groups, and local government; and members of the public interested in the project. Turn-over among participants was expected as were the costs of replacing lost contributors. However, changes in agency leadership proved particularly difficult. SNAMP was initiated as a solution to conflict at the highest levels of federal and state government, but over the project's eight year run, political transitions at both federal and state levels directly impacted the project. Specifically, SNAMP originated under Republican political leadership that later transitioned to Democratic leadership in 2010. Consequently, we worked with three Regional Foresters, three Deputy Regional Foresters, three Directors of the USFS Pacific Southwest Research Station, and three Secretaries of the California Resources Agency. All this turn-over was accompanied by shifts in priorities, and after the first few years, no one in the agencies really owned the project anymore. Consequently, a great deal of effort had to be spent on briefings: persuading new leaders that SNAMP was worth the investment in time, effort, and money. Given that maintaining support for SNAMP was vital to its survival, the "selling" of SNAMP to successive leaders in state and federal agencies was a persistent, high priority task that demanded attention.

4) Navigating unbalanced institutions and non-nested jurisdictions.

The state and federal agencies that participated in SNAMP were envisioned as equal partners in the original Memorandum of Understanding that created the project (MOU 2015). As the project progressed, the reality turned out to be somewhat different. The Forest Service has the legal responsibility to manage the National Forests. The vast majority of the project's operating funds was provided by the Forest Service. In addition, the SNAMP research was conducted on National Forests, and the forest fuel treatments were implemented by the Forest Service. All this investment resulted in close engagement by the Forest Service. Some agencies, like California's Department of Water Resources, provided substantial funding and assistance but were focused primarily on a single resource and, consequently, a single research group within the UC team. Other agencies were unable to provide much funding for SNAMP but were important partners in the adaptive management process. For some agencies, the ability or desire to participate in the CAM process waxed and waned over the lifetime of SNAMP.

These varying roles and responsibilities resulted in an imbalance of input and commitment to SNAMP. This imbalance disrupted working relationships, and at several points, threatened the success and even the existence of the project. Because agencies did not have jurisdiction over one another, trying to get everyone at the table and working together was not simply a matter of issuing orders. Maintaining inter-agency cooperation required a more diplomatic approach.

5) Accommodating diverse definitions of success among participants.

Given SNAMP's multiple institutional cultures and contentious origins, variation in the definition of success was expected. Each group, including the state and federal agencies, had at least some goals not shared by other parties. For example, the California Department of Water Resources was primarily interested in the development of new technologies to assess winter water storage across the Sierra Nevada while the political leaders of rural counties with extensive National Forest lands were focused on reducing wildfire hazards in their jurisdictions. In some instances, goals were incompatible. For example, retention of big trees, a goal of the US Fish and Wildlife Service, conflicted with the fuel reduction objectives supported by the Forest Service.

Another dimension of divergence revolved around the constraints imposed by the experimental design. As noted above, SNAMP took an active approach to adaptive management by treating management as deliberate experimentation (Gregory et al. 2006; Bales et al. 2015). In several instances, aspects of conducting a successful experiment – a goal strongly supported by the science team – conflicted with the goals of the agency partners and the public stakeholders. For example, UC scientists were repeatedly asked by the resource managers for help with the treatment plans to change wildfire behavior. These requests were entirely reasonable given the expertise of the principal investigators. However from a research design perspective, having an investigator involved in both the development and the evaluation of the treatments introduced an unacceptable bias. In this case, good science clashed with better management. Project success clearly was defined differently by different groups throughout SNAMP.

Strategies

Serious challenges confront resource management projects that include collaboration and adaptive management (Allen and Gunderson 2011; Susskind et al. 2012). We were able to anticipate some problems (e.g., mismatch between scale of research products); others caught us by surprise (e.g., turnover in agency leadership). When considering the lessons learned from SNAMP, we found that the following four strategies helped keep the project on track and on task. Note that there was not a one-to-one correspondence between the strategies applied and the challenges encountered. Instead, solutions often helped ease two or more problems.

1) Standardization and consistency in scales, in terminology, and in research products.

To limit the confusion caused by multiple institutional cultures and by new personnel who needed to get up to speed on SNAMP, the UC science team decided early on to implement standardization and consistency whenever possible. For example, we agreed at the beginning of the project that regardless of the scale of the research effort, we would report all results at the scale relevant to managers – the fireshed (USFS 2004). Thus, SNAMP used simulation models and statistical interpolations to report results at the spatial scale of the fireshed (14 – 56 km^2) and the temporal scale of 1 to 30 years (Hopkinson and Battles 2015).

The UC science team also tried to use consistent terminology so that when an owl researcher said "high severity fire" for example, it meant the same thing as when a hydrologist used the term. By enforcing consistency among the UC science team, we limited the potential for confusion in conversations with stakeholders. Towards this end, the team maintained a list of key terms with project specific definitions and recommendations for usage. This glossary gave SNAMP participants a shared language – a prerequisite to a common understanding.

2) Transparency in all facets of the project.

SNAMP was born from a desire to try a different approach, one that diverged from the legacy of conflict, mistrust, and legal challenges. The UC research team was invited to serve as a neutral third party charged with developing information that could inform adaptive management in Sierra Nevada forests. But if our data and analyses were to be useful, we had to establish from the beginning that all parties could believe in the research produced by the team research (i.e., in our expertise, NAS 2016) and also rely on the team to act as a neutral party in the collaborative process (Greig et al. 2013).

To achieve these twin goals, the UC science team made its activities and decisions as open as possible to everyone, including the general public. We described and discussed workplans, budgets, underlying assumptions, working hypotheses, methodologies, initial findings, and scientific disagreements in public forums (Table 2; Pratt Miles 2013). Data were made publicly available to the extent possible (Pratt Miles 2013), and anonymous peer-reviews of the workplan and final report were posted on the SNAMP website. This kind of scrutiny was not something most members of the research team were used to and caused considerable discomfort for some colleagues. Maintaining transparency was also expensive, both in researchers' time and their enthusiasm for the project. In the cause of transparency, team scientists had to participate in numerous public meetings and field trips (Table 3), defend methods and analyses in non-academic forums, and answer online questions posed by public stakeholders.

As a neutral third party, the UC research team was committed to objectivity to the best of its ability. The team published a statement of neutrality (UCST 2010) outlining how team scientists would maintain their third-party status. A key element was the limitation imposed on team scientists. Collectively, team scientists agreed not to share their expert opinions on SNAMP-related forest management decisions based on preliminary results from their research. Scientists could only extrapolate from results already published in peer-reviewed journal articles. Interestingly, the public admission of two early violations of this policy by team researchers not only improved stakeholder confidence in the team's neutrality but also incentivized publication of initial results. Once SNAMP journal articles began to appear, concerns regarding neutrality subsided.

3) Public engagement through effective communication.

The necessity of effective communication is hardly a novel insight (Reed 2008; Greig et al. 2013) but actually following through with it over the entire run of a multi-year CAM project required dedication and substantial investment in time and effort from all participants (Susskind et al. 2012). In SNAMP, the UC science team including principal investigators, their students, and staff spent much time preparing and delivering outreach in multiple forms and venues (Table 3). This effort was considered necessary to encourage public participation (Kelly et al. 2012).

Fortunately for SNAMP, the research team included specialists and advisors from UC Cooperative Extension. These experts in promoting public engagement with science (Osmond et al. 2010) not only served as the front-line communicators for SNAMP, especially in the local communities near our two study sites, but also trained the rest of the UC science team to interface with a diversity of stakeholders in a meaningful fashion. Moreover, they facilitated all meetings, even those within the science team, helping participants to focus on goals, maintain productive dialogue, and reduce conflict.

4) Administrative capacity and flexibility to fill gaps in expertise, staff, and funding.

An important responsibility for those of us who administered the project was to provide an enabling environmentwithin which all the different groups could work together successfully. Sometimes this enabling was as simple as supporting multiple methods of group communication. In general, we were called upon to solve problems, which took the form of gaps – in expertise, in staff, and, all too often, in funding. Filling these gaps required project administrators both on the UC research team and at the agencies to be as flexible as possible. For example, early on, the project coordinator did some of the core spatial analyses while the UC Spatial Team was getting up to speed. This allowed SNAMP to adhere to its initial timeline.

Project funding was frequently insecure and required ingenuity from both project administrators and from principal investigators who had to readjust their research budgets on multiple occasions. At one point, delays in funding from a state agency meant that money was not going to arrive in time to keep a graduate student researcher paid. The Forest Service's Deputy Regional Forester stepped up to cover the expense. Filling such gaps prevented the project from floundering on numerous occasions. Some of the project's funding constraints were exacerbated by the 2008 financial crisis, during which SNAMP was almost defunded. Anticipating, to the extent possible, and accommodating these funding delays and shortfalls was an essential task for the project's completion.

To maintain flexibility, we developed contingency plans in advance of anticipated problems. Unorthodox solutions also needed to be considered. For example, the Forest Service provided the flight support essential to SNAMP wildlife telemetry, which took advantage of existing infrastructure and avoided the costs that would have been associated with the UC team deploying its own safety and maintenance protocols. The state and federal agencies also worked together to expedite permitting processes so the scientists could install project infrastructure rapidly. The agencies and the UC science team collaborated to find support for SNAMP from private foundations. For their part, all the universities involved agreed to waive their indirect costs in acknowledgement of the public benefit of SNAMP.

Summary

The promise and pitfalls of adaptive management are well-documented (Moir and Block 2001; Allen and Gunderson 2011; Williams and Brown 2014). And yet, adaptive management remains one of the best options for improving resource management decisions in a rapidly changing world (Allen and Gunderson 2011; Westgate et al. 2013), particularly when the process promotes stakeholder participation and collaboration (i.e., CAM, Susskind et al. 2012; Scarlett 2013). However, just as "resource managers and policymakers should not blindly assume adaptive management is the best strategy" (Doremus 2011), environmental scientists should not underestimate the challenges involved in collaborative adaptive management (CAM). The demands extend beyond the typical difficulties anticipated by scientists when conducting research. While SNAMP may be unique in that the science team was responsible for conducting the research and serving as a neutral third party, the engagement of scientists with stakeholders is essential to the success of any CAM project because it is the means to build trust – trust in the science and trust in the process (Susskind et al. 2012; Grieg et al. 2013; Beratan et al. 2014).

Towards this goal of building trust, we cannot overemphasize the significance of transparency. In 2014 email survey of SNAMP participants, 85% of respondents agreed with the statement that because of the UC science team's role in SNAMP, they believed that "the process is increasing trust among agency, public, and university" (Sulak et al. 2015). In the same survey, 92% of respondents agreed with the statement that the science team had made the project more transparent. We believe this correlation is not coincidental. The information that the team generated was valued by most of the stakeholders because they saw how the "sausage was made" (Sulak et al. 2015). As mentioned above, this sausage-making included the unveiling of the peer-review process. It required stout hearts and thick skins to not only post anonymous peer-reviews of the draft workplan and final report on our website but also to discuss the criticisms and revisions in public forums. This openness extended to informing stakeholders when SNAMP-related manuscripts were submitted to journals and acknowledging, in some instances, that a paper was rejected. Budget allocations were another sensitive subject not usually discussed in open forums. However, despite the discomfort and awkwardness that this open-book approach generated, we contend that it was central to the success of the project.

An important adjunct to transparency was effective communication. Most of the principal investigators on the UC science team were university professors. Thus, many of us were comfortable with the need to teach stakeholders the intricacies of the science. On the other hand, few SNAMP participants were university students and as often noted, scientists are not always the most skilled public communicators (Groffman et al. 2010; Besley and Tanner 2011). In this regard, SNAMP greatly benefitted from the inclusion of cooperative extension specialists and advisors among our principal investigators. They are precisely the “information diffusion” (Doremus 2011) and “bridging” (Allen et al. 2011) agents needed to help translate the scientific results generated from CAM to resource managers and the public.

At its core, SNAMP was an interdisciplinary research project. The benefits and costs of interdisciplinary collaboration in ecology are well-documented (Goring et al. 2014). One cost is the need to build a shared understanding among scientists from different disciplines. So, we developed a common language and consistent practices among the science team, a necessary effort that in turn supported clear communication with resource managers, policy makers, and public stakeholders.

In many respects, the support for SNAMP among stakeholders was vital to the continuity of the project through leadership transitions and budget shortfalls. Political and agency leaders are well aware that scientists assign very high importance to the value of continuing their research (Doremus 2011; NAS 2016). But our arguments regarding the value of SNAMP were re-affirmed by the community. It was not just scientists asking for more support. Thus, our vital administrative capacity – the ability to find ways to keep SNAMP alive – was linked to our success in public participation.

CAM represents one new model for how scientists can more effectively engage with the public (Pratt Miles 2013). As noted by Groffman et al. (2010), there is a pressing need to conduct research that both informs management and resonates with the general public. CAM meets both these criteria. Despite the challenges, we encourage our colleagues to embrace public engagement. It must be an essential part of our mission because without a broad public consensus, we will not be able to counter the ongoing degradation of our environment.

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Table 1. Participants and stakeholders in the Sierra Nevada Adaptive Management Project.

UC science team	**Government agency**		**Stakeholder institution** (major participants only)
	Federal	State	
University of California (UC) Berkeley	United States Forest Service (USFS) Region 5	California (CA) Resources Agency	Calaveras County Water District
			California Energy Commission
UC Merced	United States Fish and Wildlife Service	CA Department of Fish and Wildlife	California Forestry Association
			Central Sierra Environmental Resource Center
UC Cooperative Extension	USFS Pacific Southwest Research Station	CA Department of Forestry and Fire Protection	Defenders of Wildlife
			Ebbetts Pass Forest Watch
University of Minnesota		CA Department of Water Resources	Extreme Precipitation Symposium
			Lahontan Regional Water Quality Control Board
University of Wisconsin		Sierra Nevada Conservancy	Mountain Counties Water Resources Association
			National Forest Foundation
			Nevada County
			Nevada County Resource Conservation District
			Placer County
			Placer County Water Agency
			Quincy Library Group
			Resources Legacy Fund
			Sierra Forest Legacy
			Sierra Pacific Industries
			The Wilderness Society

Table 2. Methods used by SNAMP to maintain transparency.

Project element	Transparency method
Budgets	Detailed in quarterly and annual reports posted on SNAMP website
Scientific disagreements	Discussed in public meetings and in reports posted on SNAMP website
Assumptions	Discussed in public meetings and in reports posted on SNAMP website
Working hypotheses	Discussed in public meetings and in reports posted on SNAMP website
Draft workplans	Subject to anonymous peer review as well as public review; draft workplans and reviews discussed in public meetings and posted on SNAMP website
Workplan	Workplan (with responses to peer and public reviews) discussed in public meetings and posted on SNAMP website
Timelines	Discussed in public meetings and in reports posted on SNAMP website
Constraints	Discussed in public meetings and in reports posted on SNAMP website
Initial findings	Presented in public meetings and in reports posted on SNAMP website
Failures	Discussed in public meetings and in reports posted on SNAMP website
Data	Publicly available in many cases
Draft final report	Discussed in public meeting and posted on SNAMP website; subject to anonymous peer review as well as agency and public review
Final report	Final report (with responses to peer, agency, and public reviews) posted on SNAMP website and delivered to agency partners

Table 3. SNAMP outreach and communication efforts (data from Sulak et al. 2015 and project manager notes).

Venue/Media	Description	Number
Website	Included events calendar, project documents, published journal articles, project reports, UC research team quarterly updates, project statements on neutrality and data-sharing, FAQs and science briefs explaining published SNAMP research articles, meeting agendas, presentations, and notes; on-line questions answered by UC scientists; meeting and fieldtrip photographs	700+ documents; approximately 200,000 views
Newsletters	Available online and in hardcopy; highlighting a resource-specific team's work or a research topic	16 issues
Public meetings	Quarterly (2005-2007) or annual (2008-2015) meetings; in-depth, resource-specific meetings	33 meetings
Outreach presentations	To local community groups, industry and environmental organizations, schools, local and regional government bodies	166 presentations and other outreach efforts
Public fieldtrips	To SNAMP study sites	29 field trips
Webinars	Online in-depth, resource-specific presentations	7 webinars
Blog postings	Highlighting recent project events or research findings	19 blog posts
Facebook page, Flickr photos, and Twitter posts	Highlighting upcoming project events or research findings	87 Facebook posts; 740 Flickr photos; 7 Twitter posts
Media interviews	For reports in media outlets on research findings	26 interviews

Table 3 (continued)

Outreach technique	**Description**	**Number**
YouTube videos	Introductions to SNAMP and resource specific research, interviews with stakeholders, short talks by researchers, demonstrations of field methods and equipment	11 videos
Learning workshops	Research methodology (e.g., remote sensing applications by spatial team), CAM facilitation by Cooperative Extension	29 workshops
Peer-reviewed publications	In scientific journals; also one book chapter	48 papers
General interest articles	In local or regional newspapers, magazines, and newsletters of local or regional organizations	8 articles