Evaluating the Impact of Climate Science Produced in the Southwest and Northwest Climate Adaptation Science Centers on Resource Management Agency Decisions

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Introduction and Project Background

The impacts of climate change are already being observed in our ecosystems and communities. Decision makers at all scales are looking for the best scientific information to guide their decisions about adapting to and mitigating the negative effects of climate change. The mission of the Climate Adaptation Science Centers (CASCs) is to deliver science to help fish, wildlife, water, land, and people adapt to a changing climate.

Beginning in late 2013, we began a process of developing an approach to assess how knowledge was being produced between and among researchers and natural resource management practitioners in projects funded through the CASC network. Our project began in the Southwest CASC and expanded to the Northwest CASC in 2015. Here were present the findings of our assessment of 16 projects; seven from the Southwest region and nine from the Northwest.

Our goals were first to develop and pilot a framework for evaluating collaborative climate science research projects (Wall, Meadow, and Horangic 2017), then to apply it to CASC-funded projects in an effort to provide CASC funders with feedback about the processes and outcomes of the projects. We used the 16 projects from the SW and NW to pilot our proposed framework. As this is the first effort to evaluate the impacts of CASC-funded research on agency decisions, we consider this to be baseline data about the two CASCs that will be most useful when used in conjunction with future evaluations that can demonstrate growth and change within the Centers and catalogue the management decisions associated with those changes over time.
Based on the CASC goal and mission, which was drawing from literature on co-production of knowledge and actionable science, we based our framework around a theory of change that states that intensive engagement between researchers and practitioners throughout the research process will yield more usable scientific findings and more use of findings by the practitioners involved. We designed the evaluation framework to explore, to as great an extent as possible, the type, timing, and intensity of engagement between researchers and practitioners (Wall, Meadow, and Horangic 2017).

We report here on the types of engagement we documented in the 16 cases and the points at which engagement occurred during the projects. Types of engagement provides insights into how much interaction occurred between researchers and practitioners. The points of engagement provided additional details about the extent to which practitioners were involved in various aspects of the research process itself. We then explore the impacts of these project on the practitioners and agencies involved: *conceptual impacts* such as improved understanding of an issue, *instrumental impacts* such as use of research findings to inform or support agency decisions and actions,

capacity-building for practitioners, *enduring connectivity* between and among researchers and practitioners, and *attitude changes* about engaged research.

Approach and Methodology

Case Study Selection

To select the cases from the SW CASC, we used a criterion-based variation sample of the 13 projects that had been funded by the SW CASC at the time our project began in late 2013. We sought a range of environmental sectors, management agencies, and type of research team (led by the U.S. Geological Survey or an academic researcher). We also included two projects recommended by the SW CASC director because of their scale and sectors addressed. In the NW CASC, we used a combination of random selection and recommendations from the CASC leadership and Stakeholder Advisory Committee. The directors of each CASC invited each principal investigator (PI) from the 16 projects to participate in the evaluation experiment.

Interviews

We conducted semi-structured interviews with each project PI, any other members of the research team who had been directly engaged with practitioners during the project, and any practitioners who had been involved or who the researchers indicated had received and/or used the research findings. The interview guide was based on our evaluation framework (Wall, Meadow, and Horangic 2017), which builds on a conceptual model that links the amount of engagement between researchers and practitioners to usability and use of research findings by practitioners (see Table 1). The framework looks at specific engagement variables such as timing, quality, and mode of communication; points of practitioner engagement within the project; and participants' perception of the quality of engagement.

Interviews were semi-structured to allow for a balance of collecting specific information about project processes, outcomes, and impacts as well as allowing interviewees to expand upon issues of significance to them. Interviews were conducted in-person whenever possible; however, most were conducted by phone because travel was not always feasible. Interviews were recorded and transcribed. We interviewed 79 people; 31 researchers and 48 practitioners.

Table 1: Indicators of successful collaborative production of climate science research with impacts on resource management decisions.

	Indicators
Inputs	Resource management agency/organization initiates project
	Pre-existing relationship between researchers and agency representatives
	Detailed engagement plan is included in proposal
	Proposal specifies research will inform decision making
	Proposal is at geographic and temporal scales relevant to agency representatives
	Research team has appropriate science background
	Research team experience with or training in collaborative research methods
	Agency contributes financial and/or in-kind support
	Boundary organization is involved in the project
Process	Agency representatives participated in which of the following project activities: project visioning, problem definition, development of research questions, research design, data collection, data analysis, interpretation of findings, testing results, disseminating results.
	Agency representatives satisfied with engagement process
	Research team satisfied with engagement process
	Agency representatives perceived that outputs were accessible
	Agency representatives perceived that outputs were timely
Outputs	Peer-reviewed publications
	Grey literature/reports
	Workshops for decision makers
	Academic presentations
	Decision-support tools
	Other (media reports, etc.)
Outcomes	Agency representatives perceive that project goals were met
	Research team perceives that project goals were met
	Agency representatives perceive that science is credible
	Agency representatives perceive that science is relevant
	Research team is aware of how science is likely to be used by agency representatives
	There is mutual interest in future collaborations
Impacts	Conceptual uses (describe)
	Instrumental uses (describe)
Context (examples)	Turnover in agency representative(s)
	Agency has capacity (technical and/or financial) to manage and use new information
	Catalyzing event affected perceived need for new information
	Opportunities are available for agency to use new information

Surveys

When project participants were not available for interviews or when we required only brief follow-up information, we asked them to complete an online survey about their experiences with the project. Surveys were a mix of closed-ended (i.e. multiple or multi-choice questions) and short open-ended questions. Surveys covered the same material as interviews, although in less detail. We surveyed 36 people; 29 were practitioners and seven researchers.

Qualitative Data Analysis

Interview transcripts, project proposals, project reports, and survey results were coded using the categories of our evaluative framework as a code book. Once the data was arranged into categories, we could identify presence and absence of various activities or factors in each of the 16 projects.

Bibliometric Analysis

In addition to exploring the use of findings by those directly engaged in each project, we sought to assess the extent to which CASC-funded research was reaching an audience *beyond* those practitioners directly involved in the projects, we employed a bibliometric analysis method (following Evely et al. 2010; Spaapen et al. 2011; Bornmann, Haunschild, and Marx 2016) in which we identified any citations of project outputs (peer-reviewed publications) in non-academic documents such as management agency documents. To track the citations, we first identified all project publications through search of final project reports, funder websites, Google (by grant number and project title), and direct inquiry of the PI. Using Google Scholar, we then searched for each publication title, and used the "cited by" function to identify the number and type of citations (i.e., academic, agency report, grey literature, conference proceedings, and theses and dissertations). We chose Google Scholar (e.g., over Web of Science) for its effectiveness in identifying grey literature, which is not available through academic databases. We include a report on the bibliometric analysis in Appendix A.

Findings

We did not evaluate the scientific merit of these cases. Research programs have well-established metrics for such evaluations such as number of publications and journal impact factors (Hicks et al. 2015). We focus solely on the use of research findings and engagement processes that may have influenced the ultimate use and usability of the findings.

Participant Demographics and Backgrounds

Projects funded through the CASC network can be awarded either to researchers from participating universities or the U.S. Geological Survey (USGS). In the 16 cases we explored, 10 of the projects were led by university-based researchers, five by USGS researchers, and 1 by researchers based primarily at a tribal agency that was a CASC partner. All the projects included co-investigators as part of the research team. Five of

the projects included both university-based and USGS researchers. Two projects (one led by a university team and one led by USGS) partnered with a consultancy.

Most project proposals (12) listed federal agencies as a key group of practitioners to be engaged during the process. However, five projects included a mix of practitioner representatives including state, non-governmental organization (NGO), or regional organizations. One project was aimed primarily at a state agency and two projects were engaged solely with tribal agencies.

Researchers brought a range of experiences to the CASC projects. All brought expertise in their scientific disciplines; however their level of experience working collaboratively with practitioners varied. Collaborative research methods are a unique skillset; lacking these skills can hinder efforts to develop a rigorous, equitable, and truly collaborative research project (Cvitanovic et al. 2019; Mach et al. in review). We found that most (12) of the PIs had prior experience working with natural resource management practitioners. The amount of experience ranged from years of consistent engagement and collaboration (i.e. so many common projects that a practitioner struggled to distinguish the CASC project from other on-going collaborations) to one or two prior projects that involved engagement or communication directly with practitioners. Only two of the projects included researchers who had formal training in collaborative research methods. In three cases, the researchers did not have any experience or formal training in collaboration (although one research team regularly interacted with practitioners through a working group – but not through a research collaboration).

Direct Engagement

Most project participants reported communication via phone and email during the projects. Participants described talking with each other anywhere from weekly to quarterly during the course of the project. Several participants noted that the frequency of communication varied depending on the phase of the research.

We also asked participants about other forms of engagement during the projects. One-on-one or small group meetings that were specifically focused on the project occurred in eight of the projects (Figure 1). Participants often noted some logistical challenges associated with them. When researchers and practitioners were not in the same location, meeting in person was much more challenging; several participants noted the additional costs (time and money) associated with travel. However, most people also acknowledged the importance of in-person meetings, when they were possible, because in-person meetings seemed to ease communication and build partnerships.

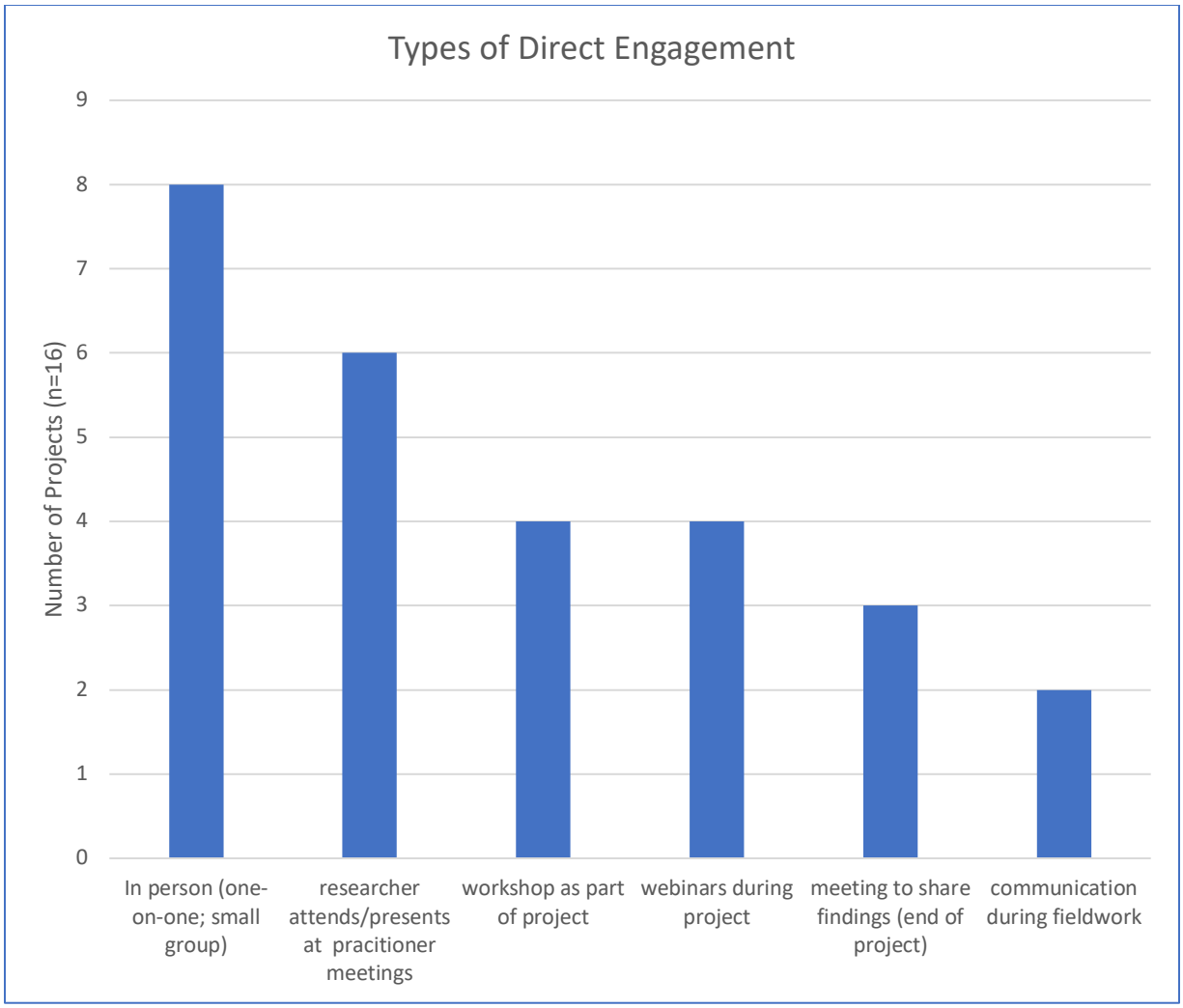

Figure 1: Types of direct engagement between researchers and practitioners over the course of the projects.

In six projects, researchers attended and/or presented at practitioner meetings. These meetings might not have been specific to the project, but they provided opportunities for researchers and practitioners to meet in person, and for researchers to update their immediate partners as well as the broader practitioner community about research findings. Having researchers show up to participate in practitioner-focused meetings was appreciated by several of the practitioners we interviewed. One practitioner explained that the researcher he worked with attended almost all of the species-focused working group meetings throughout the year and that "she's one of the few that actually understands that when you have science and you want to deliver it to the managers, you have to bring that paper to the front door. You can't leave it in the . . . newspaper stand." When asked what set apart a researcher from others he's worked with, another practitioner explained simply, "[He's] very good about showing up. I personally interact with him in terms of emails back and forth. He always flips out an email when there's a new publication. He's there if we've got a workshop."

Four projects included some form of collaborative workshop (that included key practitioners along with a broader group of researchers and practitioners) within their project activities, providing an opportunity for the researchers and practitioner to have dedicated time to work on the project. One of the projects used workshops with practitioners as an integral part of their research work and another held a workshop with practitioners to present research findings and spur broader discussions. A practitioner who participated in the workshop-intensive project explained, "[I was involved] as much as I could have been! I attended most of the workshops. Relative to other activities, this was a bigger commitment – but I was happy to make the time because it was an important topic and I was getting something substantial back."

Four projects included webinars to deliver research findings to practitioners. In three projects, in-person meetings at the end of the project were the primary vehicle to deliver research findings to practitioners.

Although practitioners in five of the cases reported that they participated in data collection activities (see Figure 2 below), practitioners from only two of those projects specifically discussed using joint data collection activities as an opportunity for engagement and communication.

In addition to the engagement activities that were relatively common across the projects, several projects used other forms of engagement to enhance their collaboration. In one project, the researchers and practitioners co-presented preliminary findings at a conference. In an effort to gather more information about practitioner needs, researchers in another project created and disseminated a survey to practitioners in the region, which helped inform the ways in which they presented their findings. And a practitioner in one project specifically discussed the fact that he and the lead researcher had carved out time while they were both at a conference to spend time together outside of the meeting, an activity he felt contributed to their working relationship.

Financial Engagement

Five of the projects we explored were partially funded or supported (via in-kind contribution) by a natural resource management agency. Financial support can be an indicator of practitioner support and future use of research findings (Spaapen and van Drooge 2011). Although there were too few instances of financial interactions to draw any conclusions about their role in research use, continuing to monitor this indicator may prove helpful as the number of projects evaluated grows over time (Meadow 2018). We acknowledge that the CASCs cannot require such support from agencies.

Points of Engagement

We asked practitioners which aspects of the research projects they participated in directly. The most common engagement activities for practitioners were data interpretation or review of findings (which includes activities such as reviewing and

commenting on research reports at the end of a project) and sharing or disseminating the research findings to others (both 10 of 16 projects). We consider sharing findings an indication that the practitioner trusted the results. However, previous research suggests that projects with engagement activities earlier in the process tend to demonstrate more impacts resulting from the projects (Meagher, Lyall, and Nutley 2008; Lemos and Morehouse 2005).

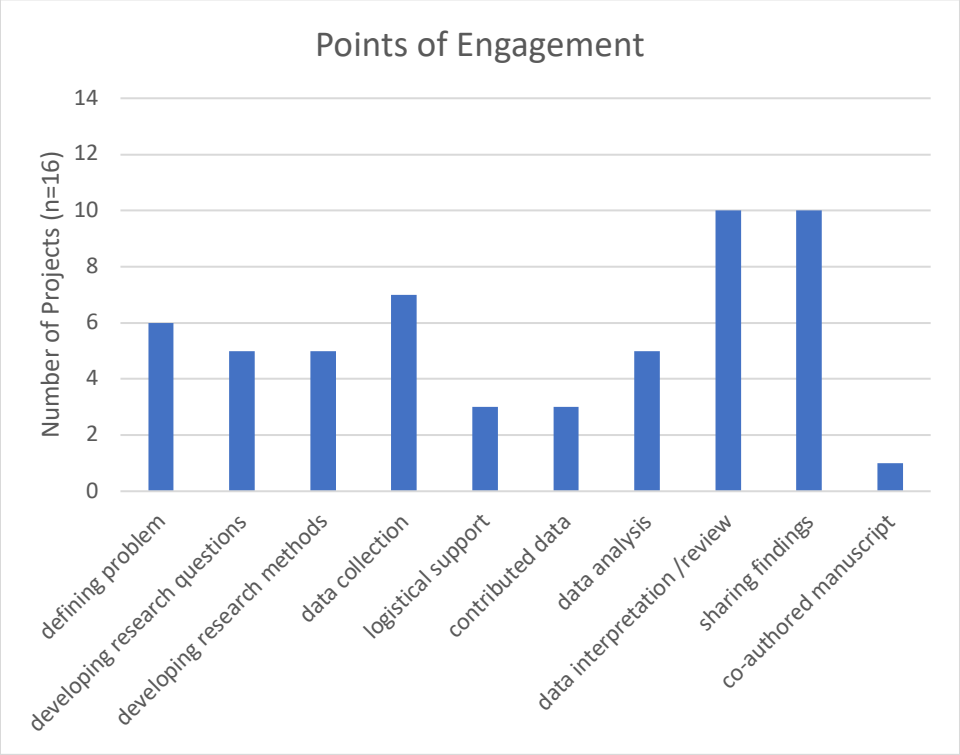

Figure 2: Points of practitioner engagement during the research process.

Six projects included engagement at the point of defining the problem, an indication that those researchers were working with practitioners early in the projects to ensure that practitioners' conception of the issue was shaping the research efforts. Seven projects included practitioners in data collection. As discussed above, only two project's practitioners identified field work as an opportunity two-way for communication or engagement, however, meaning that in five projects the practitioners participated in that research activity but it was not necessarily an opportunity for engagement during the process. Figure 3 summarizes the frequency of multiple points of engagement in the projects; the highest number of points was seven, which one project exhibited.

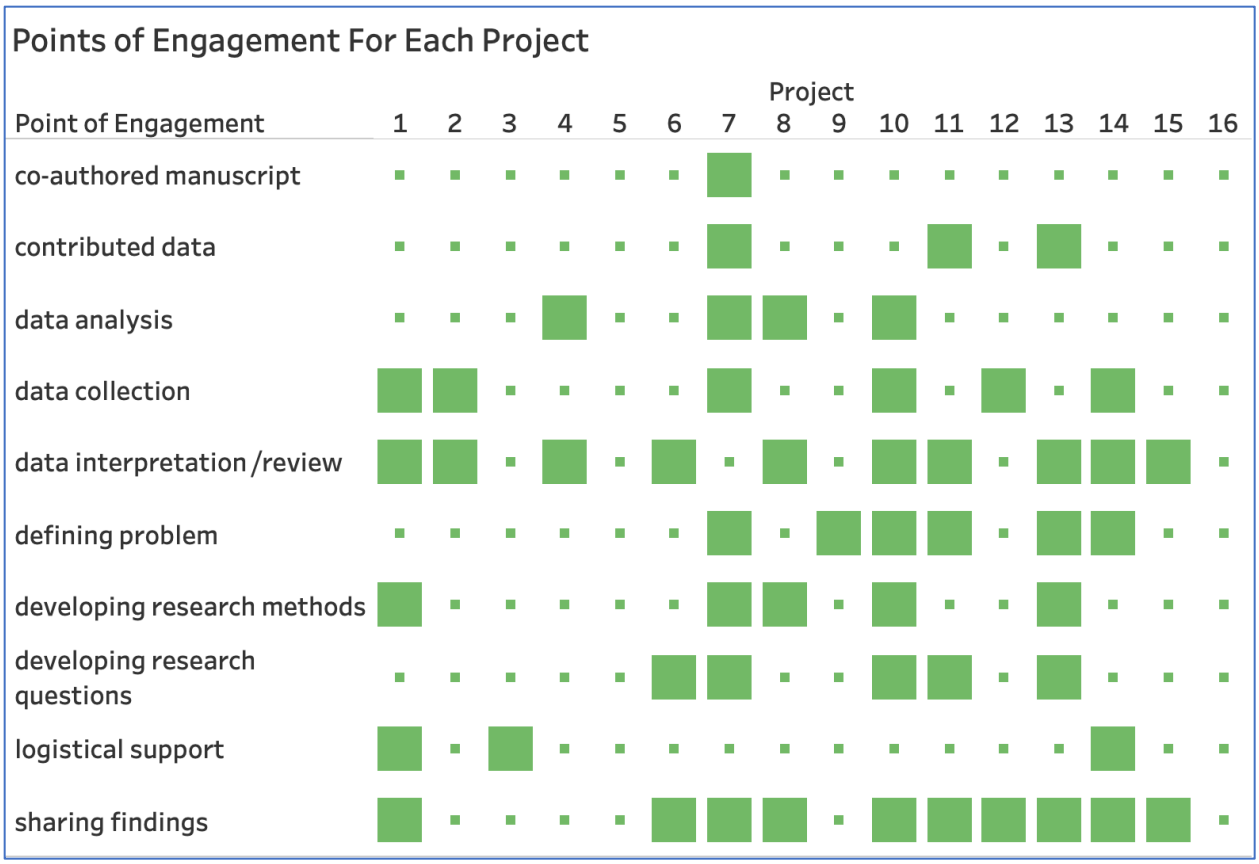

Figure 3: Points at which practitioners were engaged in the research process.

We noted that two of the projects that received significant positive feedback from practitioners did not demonstrate multiple points of engagement (i.e. the practitioners did not participate directly in most of the research activities). However, the practitioners reported consistent communication throughout the project in such a way that the practitioners felt that the researchers understood and addressed their questions, even thought they were not directly engaged in the acts of research. For example, one practitioner appreciated the way in which the researchers gave her opportunities to respond to the findings that fit within her busy schedule:

> That's been really good because just from the amount of stuff I have to do I can't be involved a ton. So, it's been really great when they provide me some information and I can look at it and talk with specialists that I work with . . . about how it's going to be useful and then provide feedback back to the group and then they can modify it. So that has worked great.

One of these low-engagement-high-satisfaction projects emerged from a long-standing relationship between the practitioners and the researcher, which gave the researcher deep insights into resource management needs. The other project was making new connections with practitioners; and the researchers seemed to prioritize communication

and the tailoring of analyses to fit (as closely as possible) the specific questions posed by their practitioner partners.

Satisfaction with Engagement

For the most part, project participants – both researchers and practitioners – were satisfied with their level of engagement in the projects. We found that practitioners in nine of the 16 projects were *generally satisfied* with their level of engagement in the project. Researchers in seven of the 16 projects similarly felt *generally satisfied*.

However, because we interviewed multiple practitioners from most projects, we found that the level of satisfaction was not uniform among all practitioners. Practitioners in 12 of the 16 projects reported that they were *moderately satisfied* but would have liked to be more engaged than they were; seven of the 12 were projects in which other practitioners had reported overall satisfaction. The pattern with researchers was similar again – in 8 of 16 projects the researchers reported a desire for more engagement than had occurred with an overlap of 3 projects with the *generally satisfied* group.

Finally, practitioners in 5 of the projects were *not satisfied* with their engagement and attributed the low levels to project-related conditions (as opposed to workload constraints). One researcher also expressed dissatisfaction due to project-related conditions.

Constraints on Engagement

The most commonly discussed constraint on engagement was the issue of sufficient time for engagement due to other work priorities (6 of 16 cases). Although this was discussed most often by practitioners, researchers also discussed the struggle to engage in the way they would have liked given their other work responsibilities. Several researchers also noted that they perceived that practitioners were too busy to engage in the project. This dynamic is well-known in the fields of engaged and participatory research (Foster 2010; Cvitanovic et al. 2015; Cvitanovic et al. 2019).

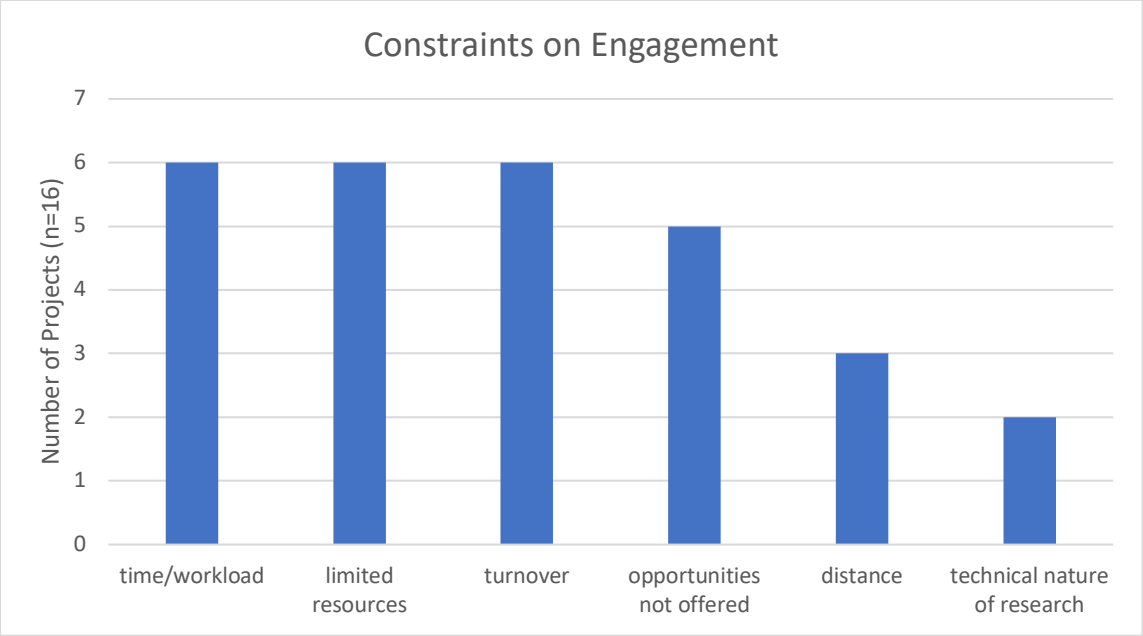

Figure 4: Constraints on engagement as described by researchers and practitioners in the 16 projects

Several practitioners explained that they perceived that their agencies had not taken steps to get engaged early enough or did not have the capacity to participate fully. One practitioner explained how lack of early engagement by her agency reduced the usability of the research, in her opinion.

> I think our [branch] did not pull the field biologists in early enough to help define data or design questions. Developing the hypothesis, with folks on the ground . . . might help with the understanding of the product and its usefulness in recovery work. I felt that I had to "catch up" folks I worked with on the development of this work and how it might be used . . . consequently, we have a small sample of folks that understand how it can be used.

A perceived lack of resources was also common (6 of 16 cases). Researchers were the most likely to express this frustration; they were the most likely to have funds dedicated to the project. However, one practitioner shed light on the resource issue from his perspective when he explained that, as a grant-funded employee within his agency, he struggled to justify his time on the project because there were no funds allocated to his role.

Other constraints included turnover of practitioner agency staff, which four researchers described as having a detrimental effect on their collaborations. On the flip side, two practitioners explained that they did not feel fully engaged in their projects because they had joined them late and did not feel fully up-to-speed or able to make suggestions once the process was underway.

The physical distance between the researchers' home base and the sites or practitioners with whom they were working was raised as a constraint by practitioners and researchers in three projects. They noted, for example, that the distance meant that researchers were cramming a lot of work into short visits, that travel costs (financial and time) increased with distance, and in large regions it simply wasn't possible to travel to visit several sites in-person. An interesting issue was raised by two practitioners who noted that they felt less able to fully engage because of the technical nature of the research being done.

When practitioners were unhappy with their level of engagement, they tended to perceive that they had not been asked for input, or were asked for their input too late in the project. For example, one practitioner explained that she felt that the project had been completely designed before she was invited to participate and that the particular design was not appropriate to their site.

> The feeling was they came up with a project already completely designed without any input from us and there were some problems with it that they might have been able to work around if they'd talked a little more at length to us beforehand . . . I think it would have gone better if we'd been included as more of a real collaborator. My experience with this project was that they came, they did it and then they sent us a draft report and . . . I spent several days revising the report. Extremely frustrated because it could have been avoided if they'd included us more.

We found that researchers in one of the projects were very reluctant to engage with practitioners during the research process because they were uncomfortable sharing preliminary findings before they had been scientifically vetted. While we noted that this instinct seemed to come from a genuine desire to "get the science right" before moving it into the management realm, we were struck by the discomfort with the process of collaborative research exhibited and not that it reflects entrenched views about the separation of science from society that are antithetical to the goals of engaged and collaboration forms of knowledge production.

Additional feedback from practitioners about engagement practices included a desire for longer-term engagement opportunities. One practitioner, who was very happy with the extent to which he had been engaged in a project, also explained, "[Researcher] did a much better job of engaging people than most projects! But, 2-3 years is enough to get going - not to sustain a learning process."

As noted above, sometimes within the same project practitioners had different perceptions of their level of engagement. For example, in one project, a practitioner praised the researcher for her attitude toward and efforts working with agency representatives, saying:

> In previous projects with professors I've always felt there's a little bit of friendly snobbery . . . There's no snobbery in my relationship with [researcher]. Because I think she being in the applied research realm, she's more interested in . . . making sure that information is produced in a way that's applicable to real natural resource problems.

Yet, in the same project, another practitioner reported that she was frustrated with the research team because she had not been invited to be directly involved, despite the fact that she had written the research team a letter of support for their proposal. In another project that garnered high satisfaction amongst most practitioners, one practitioner reported that she felt that she had been excluded from the research process.

These varied responses point to the need to gather feedback from as many participants as possible in order to gain a broad perspective on project processes and outcomes and help avoid situations in which one experience (good or bad) is taken as representative of all experiences.

Impacts

This section deals with the direct impacts to the practitioners who were involved in each of the 16 cases or the agencies they represent. As discussed earlier, several projects resulted in uses of findings beyond the direct partnerships; these are addressed in Appendix A. Here we focus on impacts that emerged for the practitioners and agencies most directly involved in the projects; this focus is due to the CASC's interest in furthering collaborations between researchers and practitioners and from evidence from many other sources that demonstrates a link between level of engagement and use and usability of the resulting research findings.

Our original framework relied on Pelz's (1978) three-part typology of how information is used in public policy-making:

- Conceptual use such as when an agency or individual is better informed of an issue or other intangible impacts.
- Instrumental, where information is used to inform a new decision or action.
- Symbolic (also termed legitimative or justification), where information is used to substantiate a decision already made.

We completed a preliminary analysis of impacts based on this typology (VanderMolen et al. in review). However, subsequent analysis of the data on impacts revealed that several of the impacts risked being "lost" or undervalued in this typology. We re-categorized the impacts data using Meagher et al. (2008) and Meagher and Martin (2017), who add three categories (and removing symbolic):

- Capacity-building – training and/or developing abilities

- Enduring connectivity – establishment of long-lived external relationships
- Attitude/culture change – increased willingness to engage in collaborative research activities on the part of individuals, institutions, or organizations

Conceptual uses of research findings tend to predominate in studies of the use of academic research by decision makers (Amara, Ouimet, and Landry 2004; Meagher, Lyall, and Nutley 2008). There are several explanations for this pattern including barriers within organizational culture that impede acceptance of new information (Choo 2006; Oh and Rich 1996; Oliver et al. 2014), meaning agencies may need substantial time before acting upon new information, although they may use the information in the sense of gaining greater awareness of an issue. The time lag from generation of research to instrumental use of research findings is uncertain and can be considerable (i.e years to decades), depending on the field of research, complexity of the question, and capacity of the practitioner organization (Penfield et al. 2014).

We were able to identify uses of the research findings (i.e. impacts) in 14 of the 16 cases. The goal of this analysis was to generate baseline data for the CASCs about the kinds of interactions and impacts that occur in CASC-funded project – not to evaluate any individual project or CASC. This is especially important to note because none of the participants involved in these projects were given explicit direction regarding the type of interactions or impacts expected by the funder (VanderMolen et al. in review). It would be unethical to evaluate any individual project on the basis of criteria not supplied to the participants and to which they did not agree. Therefore, we emphasis here the types of impacts we observed in these cases, not the overall number of impacts and we make no efforts to rank projects according to impacts.

In both cases where we could not identify any impacts, we found that the projects had not proceeded as planned and there was little-to-no engagement with practitioners; therefore, we were not able to contact practitioners about their experiences in the project or uses of research findings.

Many of the cases resulted in more than one use of research findings or other impact. When we could verify a specific impact – such as citation in an agency document or informing future work in an agency, we counted all instances of use for a project (i.e. if several practitioners from different agencies provided examples of use, we counted each one). For more intangible examples of use, such as practitioners feeling better-informed (conceptual impact), we counted only the type of use once, regardless of whether more than one practitioner reported this outcome. We made this distinction because, in some cases we were able to contact several practitioners while in other cases only one (or none) were available to respond to us. We did not want to weight our findings based on how many people were able to respond to our questions. We err on the side of presenting the types of uses that emerge from the projects, rather than evaluating the overall number of impact examples.

Research impacts often emerge over time and an evaluation such as this one can only present a snapshot of impacts at the time of evaluation. These findings present an overview of the types of impacts that emerged from these 16 projects at the time of analysis. Findings are summarized in Table 2.

Table 2: Types of Impacts Demonstrated by NW CASC-Funded Projects

Type of Impact	Examples	Number of Projects
Conceptual	Practitioners reported being better informed about the issue. Practitioners reported sharing the findings with others. Practitioners used research findings in their own communications/outreach to agency stakeholders. Findings spur agency's own research efforts.	12
Instrumental	Informed management decisions (including deciding against a particular action). Informed resource allocation decisions. Cited in management plans. Cited in guidance or opinion documents.	10
Capacity-Building	Findings provided agency with new data and/or data were incorporated into existing decision support tool. Fieldwork provided valuable experience for agency staff. Findings used to support funding applications.	5
Enduring Connectivity	Workshop formed the basis of emergent community of practice. Practitioners reported being willing to or interested in working with the research team again in the future.	14
Attitude Change	Research group realigned its own work priorities in response to greater understanding of practitioner needs.	1

Conceptual Impacts

Practitioners in most projects reported that they were better informed about the issue under consideration after the project (12 of 16 cases). In the remaining four cases, we had no practitioner input from three; in one case the practitioners replied that the findings were not salient to their work and they did not feel better-informed. For example, one practitioner from an NGO explained how the research findings provided a broader perspective on a key issue for their organization.

> Yes, he's giving me what I want because he's pulling together a holistic picture. [For most other species] we're working with partial insight. [For this species] we have a more comprehensive picture, largely because of the work that [researcher] has led. I think this enables us to craft more effective, implementable, and sustainable solutions.

In 10 projects, practitioners reported that they shared the research findings with others in their professional circles. Another practitioner explained the importance of sharing new findings within his agency:

> Well, I'm using it at my level and above to promote and make people aware of relevant work . . . and to provide technical assistance to our own folks because a lot of the criticisms [within] the agency or the perception is, 'What are you [regional offices] doing for us? We don't understand it, we're not aware of it. We don't believe you're doing much to help us.' So, I'm using it a lot to explain to people what is going on that they're not aware of and some of the briefing materials that [researcher] has produced are very powerful.

One practitioner explained his use of the research findings in a way that illustrates how agencies often take a step-by-step approach to integrating new findings into their decisions; conceptual impacts eventually leading toward instrumental impacts.

> We've prepared a watershed conservation plan, which essentially makes recommendations on additional specific modeling that should be done by applying the results of the research. Then we will continue to update that watershed conservation plan based on the results of [researcher's] continued involvement in this project.

We found several examples of agency personnel using the research findings in their outreach to agency stakeholders. "We would use the [findings] from this project as part of the background information to present to the stakeholders, people, . . . whatever level they are, policy makers . . ." explained one practitioner.

Instrumental Impacts

In the instrumental impact category, 10 projects generated examples of instrumental impacts. We identified one example of the research findings being used to support proposed management actions. An agency planned to use the findings to inform the placement of physical barriers linked to achieving their species conservation goals. In this case, the action itself had not yet occurred at the time of data collection – but the agency seemed poised to act, and acknowledged the research findings as playing a role in their decision. In another case, a practitioner reported that the findings helped his agency steer away from a particular action because the research showed it was ineffective.

The more common form of instrumental use was citation of project findings in agency documents like resource or species management plans or policy guidance documents like Environmental Impact Statements. While these plans form the basis for the kinds of actions we noted above, we were not able to verify whether specific actions had been taken as part of these plans, thus we elected to include citation as an instrumental use, but differentiate it from the cases where action had clearly been informed. In one project, a practitioner explained that his agency's watershed conservation plan made explicit recommendations about future modeling that should be done applying the research results from the CASC project. Similarly, another agency made recommendations about the use of models produced in the CASC project in their future species management plans.

Capacity Building, Connectivity, and Attitude Change

Several practitioners noted that the CASC research projects were helping to spur new research efforts within their own agency. One practitioner even hired a graduate student to explore a particular species of concern in greater depth because of what he'd learned during the CASC project. Another form of capacity building came from agency personnel participating in research fieldwork, which their supervisor described as "a good learning opportunity." We also included examples of a project providing an agency with new data as a form of capacity building because that new data enhances the agency's resources.

The workshop held as part of the presentation of research findings in one project brought a number of regional stakeholders together for the first time. A group of them continued to collaborate on funding proposals and broader discussions of regional concerns, an example of enduring connectivity emerging from a CASC project. "In think the workshop was part of the momentum building in this region around the field of climate change," explained a workshop participant. We also found that representatives from 14 of the 16 projects indicated a willingness to or interest in working together again in the future, an indicator that connections were built, maintain, and likely to be sustained through these projects.

An interesting example of attitude change came, not from a practitioner, but from one of the research groups. The lead researcher from the group reflected upon his experiences working directly with practitioners and realized that there were ways to change his program to better respond to practitioners' needs, "especially those without the resources to contract with [us] directly."

Possible Future Uses

In keeping with our understanding that impacts from research emerge over time at an unknown rate (Edwards and Meagher 2019), we noted a number of examples of practitioners describing how they *hoped* or *planned* to use the research findings, despite not having been able to act on them at the time of our analysis.

One practitioner speculated that "I'd imagine what's going to happen is it's going to be included in the [species] GIS, which will then be used in kind of advanced analysis to identify areas of prioritization for restoration." Another suggested that, once the project results were finalized, he might be able to use them to secure funding for adaptation actions. Although he had not received the research findings in final form yet, a practitioner noted that an upcoming planning document his agency was required to produce would greatly benefit from the research findings. He also noted his hope that the findings eventually "would be actually used to adjust operations plans; to look at [specific] plans and evaluate them in the face of this new information."

Barriers to Use

In several cases, practitioners pointed to specific reasons why they did not view the findings as usable or did not expect them to be used in an instrumental manner. Several practitioners noted that findings were not explicitly linked to possible actions or were not relevant at their local or decision-making scale. One practitioner, who benefited from the enduring connectivity impact, went on to describe his frustration with the content of the research findings.

> The research itself seemed a little . . . it wasn't directly linked in a clear way to restoration projects or restoration design. It was kind of useful information to have for planning and for thinking about stuff, but it wasn't a directly applied type of thing.

Several practitioner perceived barriers to action within their own agencies related to lack of capacity or willingness to act and lack of funding to take action. One person explained that he did not perceive "any resistance to the problem. I think the bigger problem is how we are ever going to get enough money to deal with this problem?" Other practitioners pointed to a common perception that new information, particularly information considered "uncertain" can hinder action (Reed and Meagher 2019). "Decision makers are somewhat reluctant to accept project data anyway," explained one person. Another noted that "There's enough uncertainty around some of the data

that people are going to be very cautious in changing their management from that perspective because of the long-term potential negative economic consequences." Finally, we found a case in which practitioners had been expecting to use the findings to take management action, but a change in leadership at the highest level of their agency, just before the findings were complete, meant a reversal of policy and the abandonment of anticipated management actions. This is an important consideration when evaluating research impacts – there will be times when, no matter how exemplary the process and outputs, the research will not be used because of factors outside the control of the researchers or the participating practitioners.

Discussion

Engagement Processes

The 16 projects represented in this evaluation broadly fell into patterns of moderate levels of engagement between researchers and practitioners (with several notable exceptions), as illustrated by the *points of engagement*, which tended to be later in the process and the overall *number of points of engagement*. Most projects fit the description of a consultative mode of engagement in which researchers consult stakeholder at specific stages of the research, then diagnose the problem and try to find a solution (Meadow et al. 2015). We also observed projects that fell in the more intensive collaborative category (stakeholders and researchers are partners and engagement is continuous) as well as examples of contractual relationships in which researchers informed stakeholders about findings, but did not include practitioners as part of the project. As we have stated elsewhere, these categories are not normative and it is possible to meet the needs of practitioners and decision makers using any of these engagement approaches. However, there is ample support in the literature for the understanding that more intensive engagement approaches are more likely to yield usable and actionable knowledge (Reed and Meagher 2019).

We found that most projects did not include detailed plans for engagement between the research team and the practitioners. We place the burden for these plans on the research side of the partnerships because it was researchers who were proposing the projects and listing their practitioner partners within those proposals. We link the lack of attention to engagement planning to two factors. First, the relative inexperience of the researchers with this form of engaged research. Although most research teams had experience working in various capacities with resource managers, which contributed to their awareness of agency needs and constraints, almost none had formal experience with social science research or collaborative research methods. This gap in awareness about the importance of structured, continuous, equitable engagement hindered these projects as less experienced collaborative researchers may have lacked the skills and training to plan and execute engaged projects effectively. (Cvitanovic et al. 2019; Djenontin and Meadow 2018). Although, we note that we observed examples of researchers overcoming their own inexperience and finding ways to engage

productively with their partners. On the other hand, in one project with a number of experienced collaborative researchers, the project did not make full use of their experience and the practitioners were dissatisfied with their level of engagement and the project outcomes. The second factor was the relatively inexperience with engaged research of the funding agency. Particularly in the early years of the CASC network, most decision makers within the network came from natural and physical science backgrounds and, therefore, had the same gap in knowledge about social science practices as we observed in the research projects. We suggest that the funders did not focus on the lack of engagement plans (and associated resources) because they were not aware of the necessity of such work for the success of collaborative research and, by extension, the production of actionable knowledge. We note that this dynamic has changed to a considerable degree in recent years and several changes have been made in the way that requests for funding are framed and proposals reviewed, including requirements for particular emphasis on the need for research teams to demonstrate their ability to engage with relevant natural resource managers (i.e. https://www.swcasc.arizona.edu/sites/default/files/data/FY17_CSC_Funding_Opportunity.pdf)

We also found that participants noted a number of constraints on engagement that are well-known in the literature on engaged-science: time constraints and funding constraints (Cvitanovic et al. 2019; Cvitanovic et al. 2015; Shanley and López 2009) as well as institutional barriers that tend to dissuade researchers from allocating the additional time and resources to applied and interdisciplinary research (Foster 2010; Bromham, Dinnage, and Hua 2016).

However, we also heard from practitioners in five projects that they did not feel as though they had been invited to collaborate or engage in the manner they would have liked. Attention should be paid, in future evaluations, to whether practitioners have been engaged in the manner described in research proposals to ensure that researchers are accountable to and respectful of their management partners. In addition, as we observed in one case, researchers not familiar with the epistemological foundations of collaborative research methods may perceive them as a threat to a standard Western scientific process (Foster 2010; Cvitanovic et al. 2019), despite evidence that that such methods are both rigorous (Greenwood and Levin 2007) and effective in moving environmental research into policy and practice (Reed and Meagher 2019). This barrier to engagement is likely to be remedied as the CASCs place greater emphasis on the importance of engagement practices in the work they fund; researchers who prefer to conduct basic research are less likely to apply for funding tied directly to engagement activities.

Impacts

Impacts from these 16 projects tended to be in the intangible categories of conceptual impacts, capacity-building, and enduring connectivity, demonstrating that practitioners

found the research relevant and often helpful, but not necessarily readily actionable. Conceptual uses are the most common form of research impacts in government agencies, placing CASC-funded research in line with many other research programs working with policy and other decision-makers (Boaz and Nutley 2019; Amara, Ouimet, and Landry 2004). Reed and Meagher (2019, 151-152) outline several reasons why environmental research, in particular, is challenging to act upon. The political prominence and broad sectoral reach of policies and substantial interaction with other policy areas; tensions arising from policy making at various scales from the local to the international; the temporal scales over which environmental processes operate; and "the complex, uncertain and often contested nature of the evidence" in the environmental science all act to make policy and practice actions more challenging. Although conceptual uses of research are generally harder to identify and track, because they are less tangible, they are important and legitimate research outcomes that 1) point to the extent to which practitioners consider research relevant and credible and 2) may act as indicators of future instrumental uses of the research after it has been considered carefully within a decision-making organization (Oh 1996; Boaz and Nutley 2019).

Other impacts from these projects included boosting agency capacity to manage climate adaptation by providing additional data, enhancing existing tools, and providing training opportunities for employees. The majority of practitioners indicated a willingness to or interest in working with the research teams again, an indicator that enduring connectivity is emerging from these projects. In two cases, we noted that practitioners credited their participation in the projects with connecting them with new networks – a more robust example of enduring connectivity. We also noted that one research group, that had not previously engaged substantially in engaged research, made changes in its working structure in order to accommodate more community-based collaborations as a direct result of their participation in the CASC-funded project. We noted this as the example of an attitude change impact.

We also identified examples of instrumental uses in ten of the 16 projects we assessed. Most instrumental uses were examples of agencies using the research in planning or guidance documents. In one case, we found evidence of the research directly informing a new management action and another in which the research helped an agency change course on an action. Because the goal of the CASC network is to generate research that can be directly used by resource managers, and although we note that the other four categories of impact are important results from these projects, we consider why only ten projects resulted in directly usable science. There are several possible explanations. First, instrumental impacts often take longer to emerge from research efforts (Penfield et al. 2014). There are multiple that factors that determine whether and when an organization might use new information, including whether an organization is prepared and able to integrate new knowledge (Oliver et al. 2014) and the level of uncertainty surrounding the new knowledge (Reed and Meagher 2019). Related to the first challenge is the question of the direct pertinence of the research findings to the

specific needs of the practitioners. If an agency does not have a window of opportunity to use the research findings in a decision, those findings, although credible and generally salient, may not be actionable. We saw this exemplified by the case in which the agency planned to use the findings in a management action until a change in policy made the action (and the findings) no longer pertinent. A third challenge emerges from our observations about the relatively low levels of engagement we observed across these projects. Based on ample research in this field, we know that increased engagement between researchers and practitioners contributes to the likelihood that research findings will be usable and used (Reed and Meagher 2019; Dilling and Lemos 2011; Reed et al. 2014). Despite the stated intensions of the CASCs to work directly with resource managers to produce usable science, we did not observe levels of engagement that are associated with collaborative knowledge production.

The factors we noted as inhibiting engagement were the lack of expertise of researchers in collaborative research methods, a real or perceived lack of resources allocated to engagement activities, and projects that did not begin on a foundation of mature partnerships. Collaborative research is a skillset that, while sometimes taught in academic social science programs, is not common in natural and physical science training (Cvitanovic et al. 2019). However, having an understanding of how to interact ethically with societal partners (Fluehr-Lobban 2008), how to build relationships and trust (Grant, Nelson, and Mitchell 2008), how to communicate scientific methods and findings clearly and effectively (Castellanos et al. 2013), and how to incorporate practitioner or local knowledge into research projects are crucial to the success of the kinds of engaged science endeavors the CASC network seeks to promote. One way in which this lack of expertise manifests is in poorly constructed engagement plans. Interactions should be structured and planned (Langer, Tripney, and Gough 2016) to ensure that they occur regularly and conveniently for all parties. However, researchers (and funders) who do not have experience with this form of research may overlook this process in favor of planning the natural or physical science aspects of their projects.

We noted a number of cases in which researchers, in particular, perceived that they had insufficient funding to pursue the level of engagement they stated they would prefer. This was often raised as an issue when discussing opportunities for in-person meetings when travel was necessary. It also became an issue for some participants because they did not have adequate salary time allocated to allow for full participation in the projects. On the practitioner side of the partnership, we found that when practitioner partners contributed funding (actual dollars or in-kind) to projects, they have more at stake (Glaser and Taylor 1973) and were more likely to both respond to researchers' engagement overtures and take an active role in defining the research and contributing to analysis in order to ensure they receive findings that align with their information needs. On the researcher side, more resources may be necessary to ensure that researchers can travel, meet, and spend time with practitioners throughout the research process. This requires a new model of funding for many natural and physical science research programs (Arnott et al. in review).

Research partners who have worked together before may be able to achieve more specific impacts in a shorter amount of time (Kothari et al. 2011) because they already have a foundation of trust, common language, and shared interests. We noted that projects built on mature partnerships moved more quickly into the current projects. However, we note that all partnerships must begin somewhere, so we do not advocate excluding projects from funding if they are relatively new partnerships; but more attention should be paid in those cases to the level of experience of the researchers and whether appropriate expectations are being set by all parties.

Conclusions

The CASC network is a relatively new enterprise, less than a decade old. This is one of the first attempts to collect data about the kinds of processes and impacts that have emerged from CASC-funded research. Because we do not have previous data to use as a baseline or comparison, we consider our findings to be best understood as a snapshot of the kinds of processes and impacts that emerged from a set of projects with a specific profile, namely:

- funded within the CASC network to supply federal resource managers with information with a focus on fish, wildlife, and ecosystems
- generally two-year projects
- project budgets between approximately $75,000 and $150,000[1]
- research teams comprised mostly (or entirely) of natural and physical scientists

The 16 CASC-funded projects that we explored as part of this evaluation process yielded positive impacts in their respective (SW and NW) regions. Ten projects resulted in findings that agencies used in policy, planning, or guidance documents, including two projects directly that informed management actions. In addition, practitioners involved in the projects overwhelmingly reported that the research had improved their understanding of environmental issues. When asked to identify barriers-to-use of the information within their agencies, practitioners noted factors such as changes in agency priorities, personnel turnover, and not being engaged early enough in the research process to influence its focus and direction.

Although we began this project with the expectation that we would identify specific engagement practices that contribute to the co-production of actionable climate science knowledge, our analysis found that the projects, in general, were not examples of deeply engaged research. We shifted our research focus to identifying and describing the types of engagement that did occur and the impacts that emerged within the context of these projects. We found that, in addition to emails and phone calls, half of the projects included in-person project-specific meetings. Several project teams arranged to

[1] One project from the SW CASC had a significantly larger budget and relied upon a network of researchers to generate the scientific content.

meet at conferences and workshops in an effort to stretch their travel funds, an adaptation appreciated by both practitioners and researchers. We noted that the majority of practitioners reported engaging at the end of projects, during the review-of-findings and dissemination-of-findings phases. Few projects included practitioners as part of the research process through the project.

Nonetheless, practitioners were generally satisfied with the effort put forth by the researchers to include them in the research process. Those who were not satisfied tended to cite their own workloads as barriers to further engagement, indicating that practitioners often lack the capacity to participate in intensive collaborative work. However, it is important to note that several practitioners were dissatisfied and linked their dissatisfaction to a sense that they were not invited or encouraged by the researchers to participate fully in the process. While it is not possible to meet every person's expectations and needs, both researchers and funders should consider whether ample resources, time, and energies were devoted to including willing and enthusiastic research partners from within practitioner organizations.

Based on our assessment of research impacts, the SW and NW CASCs are making positive contributions to resource management agencies in their regions. Our snapshot of impacts revealed that most impacts fall into the less tangible conceptual, capacity-building, and connectivity categories. Conceptual uses are most common in management agencies (Amara, Ouimet, and Landry 2004; Boaz and Nutley 2019) and decision makers often need to accumulate conceptual impacts prior to making decisions (i.e. instrumental impact) (Nutley, Walter, and Davies 2003). The capacity-building and connectivity impacts indicate the potential for emerging impacts in the future as increased capacity and increased connectivity continue interact to link increasingly capable agencies with broader communities of practice (Edwards and Meagher 2019). The ten projects that resulted in instrumental impacts indicate that CASC-funded research is often salient and usable.

Recommendations for Supporting Engaged Research

The 16 projects from the SW CASC and NW CASC we considered in this analysis have achieved a number and a variety of impacts for researchers and natural resource management practitioners in their respective regions. We suggest that the CASCs can enhance their research programs – and the impacts of those programs – by focusing on four key factors in future research projects.

- **Prioritize consistent communication and engagement throughout the project.** Two-way interactions in which both researchers' and practitioners' are active and equitable participants are a key factor in the production of research impacts and actionable knowledge (Meagher, Lyall, and Nutley 2008). Interactions should be structured and planned (Langer, Tripney, and Gough 2016) to ensure that they occur regularly and conveniently for all parties. Even in cases where practitioners were not active research participants, we found that

consistent communication of research progress and findings contributed to better overall satisfaction with projects and use of research findings.

    - Consider opportunities to support engagement prior to the submission of proposals, such as through seed funding (Arnott et al. in review) or discretionary funds to support engagement activities (Reed and Meagher 2019).
    - Set expectations that all projects include clear, feasible, and appropriately resourced engagement plans (Langer, Tripney, and Gough 2016; Reed et al. 2014)

- **Ensure that project personnel possess expertise with collaboration.** Collaborative research is a skillset that, while sometimes taught in academic social science programs, is not common in natural and physical science training (Cvitanovic et al. 2019). However, having an understanding of how to interact ethically with societal partners (Fluehr-Lobban 2008), how to build relationships and trust (Grant, Nelson, and Mitchell 2008), how to communicate scientific methods and findings clearly and effectively (Castellanos et al. 2013), and how to incorporate practitioner or local knowledge into research projects are crucial to the success of the kinds of engaged science endeavors the CASC network seeks to promote.
    - Expand upon professional development opportunities such as the NW CASC skills-building webinars and the NW and SW CASC fellows programs.
    - Professional development opportunities should recognize collaborative research as a unique skill set and include training in social science and collaborative research methods.

- **Build on existing mature partnerships.** Research partners who have worked together before may be able to achieve more specific impacts in a shorter amount of time (Kothari et al. 2011) because they already have a foundation of trust, common language, and shared interests. **Support early partnerships** by ensuring that projects have sufficient resources for consistent communication and engagement throughout.

- **Explore opportunities for shared funding responsibilities.** When practitioner partners have contributed funding (actual dollars or in-kind) to projects, they have more at stake (Glaser and Taylor 1973) and may be more likely to both respond to researchers' engagement overtures and take an active role in defining the research and contributing to analysis in order to ensure they receive findings that align with their information needs. Financial engagement from practitioner may also increase the likelihood of use of the research findings (Spaapen and van Drooge 2011)

- **Evaluate collaborative research appropriately.** The engaged research practices that are prioritized by the CASCs often take a hybrid form that blends natural and physical science research with social science, epistemology, and applied research strategies. At every stage from proposal review through project and program evaluation, methods appropriate to collaborative, applied, and action-oriented research should be used.
    - The network should ensure that proposal review panels include reviewers with expertise in collaborative research methods so proposals are reviewed effectively and fairly (Polanyi and Cockburn 2003).
    - The network should rely on evaluation methods and metrics that are suited to capturing the processes and outcomes of innovative, socially impactful, and transdisciplinary research (Arnott et al. in review; Mach et al. in review; Wall, Meadow, and Horangic 2017; van Drooge and Spaapen 2017; Owen, Ferguson, and McMahan 2019).
    - Evaluation efforts should prioritize the learning function of evaluation so that individual projects and the CASC network as a whole actively improve their practices through reflection and course correction, in partnership with evaluators working concurrently with the research process (Mach et al. in review; Arnott et al. in review; West, van Kerkhoff, and Wagenaar 2019)
    - This evaluation report provides baseline data for two CASCs; it can be used by future evaluation efforts as a tool for comparison and to measure program growth.

Robustness of Our Framework

The performance of the metrics and evaluation frameworks developed for this project has been robust. The framework has successfully allowed us to identify a range of research impacts from these 16 case studies and has allowed us to explore, in great detail, process-related variables such as amount, timing, and content of communication and engagement between researchers and practitioners. We have published five peer-reviewed articles based on this research.

Brugger, Julie, Alison Meadow, and Alexandra Horangic. 2015. Lessons from First Generation Climate Science Integrators. *Bulletin of the American Meteorological Society* 97 (3):355-365.

DeCrappeo, Nicole M., Gustavo A. Bisbal, and Alison M. Meadow. 2018. A Path to Actionable Climate Science: Perspectives from the Field. *Environmental Management* 61 (2):181-187.

Djenontin, Ida Nadia S., and Alison M. Meadow. 2018. The Art of Co-production of Knowledge in Environmental Sciences and Management: Lessons from International Practice. *Environmental Management* 61 (6):885-903.

Meadow, Alison M., Daniel B. Ferguson, Zack Guido, Alexandra Horangic, Gigi Owen, and Tamara Wall. 2015. Moving toward the Deliberate Coproduction of Climate Science Knowledge. *Weather, Climate, and Society* 7 (2):179-191.

Wall, Tamara, Alison Meadow, and Alexandra Horangic. 2017. Developing Evaluation Indicators to Improve the Process of Co-producing Usable Climate Science. *Weather, Climate, and Society* 9 (1):95-107.

Two additional papers are currently in review.

Ferguson, Daniel B., Henry P. Huntington, and Alison M. Meadow. in review. Early Stages, Early Outcomes: Exploring Initial Steps in Developing Socially Relevant Knowledge. *Sustainability Science*.

VanderMolen, Kristin, Alison M. Meadow, Alexandra Horangic, and Tamara U. Wall. in review. A typology of stakeholder information use in collaborative science. *Environmental Management*.

Two papers are in process.

In an effort at self-reflection and to acknowledge the iterative process of this type of research, we have identified several areas that either need additional research, research tools, or areas we overlooked in the initial development of the evaluation framework.

The most significant point of reflection comes from the distance between our original project goal and the reality of the case studies. We set out to explore the efficacy and

processes of co-produced research and explore how such a research approach might be used to increase the actionability of research outputs. However, those expectations did not match the cases available. Our framework, designed to explore the collaborative research process in great detail, focused too much on process to be entirely useful for these 16 cases. In retrospect, a framework that balanced the exploration of outcomes and impacts with process may have eased this research process and reduced the large volume of data, much of which was, in the end, more descriptive than explanatory.

The lack of "co-production" evidenced in these cases also raises important questions for the CASC network. Is the goal of co-production of knowledge reasonable, given the constraints CASC-funded projects face in terms of funding, timelines, and researcher training? There are significant questions to be considered about whether researchers without training in social science or transdisciplinary research can be expected undertake this form of research; whether academic institutional barriers created by the current tenure-track system inhibit this kind of work; and whether it is possible to provide sufficient funding for this type of resource and time-intensive research. We are concerned that a continued set of expectations for co-produced research, without the necessary resources, can lead to both practitioners and researchers to multi-task to the point of exhaustion and burn out (Cvitanovic et al. 2019; Chubb and Reed 2018; Oliver, Kothari, and Mays 2019). Going forward, we might begin to ask what level and types of engagement are doable that have impact, rather than privileging one idealized form of research.

Below we provide recommendations on the use of the framework in future efforts to evaluation engaged climate science research efforts.

Recommendations for Use of the Framework

This pilot project proved effective in helping us to understand the inner workings of each project. However, such an in-depth process is not likely to be practical for on-going evaluation efforts. In order to transition this framework, and project-level evaluation more generally, into practice, we suggest a focus on several key features of the research projects. We include a revised evaluative framework in Appendix B.

- **Set expectations about adequate planning for engagement**. Each research proposal should include a plan detailing how, when, and why the researcher will engage (in person or not) with their practitioner partner(s). This plan should be evaluated at the proposal review stage and again at the project evaluation stage to provide evidence of the researchers' experience and competence with engaged forms of research.

- **Evaluations should continue to use the points-of-engagement questions** as a guide to prompt discussion about the timing and level of practitioner engagement. Individual evaluators may identify additional points and should include those in project evaluation reports.

- **Practitioners must be included in project evaluations**. We noted several instances where the recollections and perceptions of researchers differed significantly from their practitioner partners. Practitioners should be interviewed (preferable) or surveyed at least annually.

- **Conceptual and other intangible outcomes from research projects should be included as project impacts**. Questions posed to practitioners should include a range of possible uses and ask for examples of uses (such as sharing findings with particular groups). The five-part typology used in this report helps to highlight intangible, but meaningful, impacts such as capacity-building and the development of new networks through connectivity.

- **Monitoring of project impacts should continue for 3 - 5 years post-project** in an effort to capture as many direct impacts as possible. Follow-up conversations with project participants after the end of the project can be brief and focused on examples of new or emerging uses of the findings.

- **Evaluation should begin when projects commence and proceed concurrently**. Retrospective analysis leaves too many opportunities for memory loss, job transitions, and confusion with other research efforts.

Future Research

After testing and working through our framework on these 16 projects (and three additional projects on which we were unable to complete data collection), we have several outstanding questions we hope can be answered in future research.

1. Not all the practitioners who participated in these projects hold the same position or play the same roles in their agencies, organizations, or communities. We would like to explore the various categories of "stakeholder" in greater detail and ask, does the role of the stakeholder within their organization change their interaction with researchers and their ability to make direct use of research findings?

2. Following the line of reasoning that the type of stakeholder role may influence both ability to engage and make use of research findings, we would like to consider the role of stakeholders' motivation in engagement and use of research. To what extent are projects successful because the stakeholders have a specific need, are interested in participating, and push for findings?

3. Our data seems to support the value of in-person activities to building solid partnerships. However, we wonder whether there are specific points within the research process where in-person activities are more beneficial than others?

4. Although we noted whether researchers and practitioners had worked together prior to these projects, and noted that pre-existing relationships seemed to ease the transaction costs of collaboration (e.g., understanding issues, communication patterns can be malleable), the factors that are valuable in aiding collaboration or how these relationships can be facilitated is not well defined. There are several key questions to be asked, including how do these long-term relationships persist despite turnover at practitioner agencies? Do these relationships shift to new people, agencies or positions when the people involved move to a new position? What is the most important function(s) of these relationships in collaborative research?

Appendix A

Bibliometric Analysis of Indirect Interactions

Indirect interactions refer to contacts that are established trough some kind of material carrier (Spaapen and van Drooge 2011). For example, researchers might use previously published practitioner documents to inform their work or practitioners who were not involved in a project might find and use research publications or data. Because all of these projects were funded through requests for proposals that were built around practitioners' explicitly stated questions and science needs, there is an argument to be made that all projects included indirect interactions in the direction of practitioners-to-researchers.

Several projects made research findings publicly available online[2]. One project used Data Basin to make their data available and several others used NGO, Landscape Conservation Cooperative (LCC), or university websites to host their data. We were not able to assess the extent to which online data was accessed or used; we simply note that it is available. While it is important to make data available for download and use, comments from one practitioner hold a note of caution about relying on web dissemination for potentially complex and technical data. He explained that he found Data Basin hard to use, even though he got help, and preferred to receive the data directly from the research team.

Another aspect of indirect interactions is the diffusion of research findings through practitioner networks that were not directly involved in the research (i.e. did not have direct interactions with the research team). We explored these interactions through bibliometric analysis of published research findings from these case studies.

Starting with the peer-reviewed publications that resulted from each of these projects (54 total), we used Google Scholar to identify government, NGO, or other practitioner documents that cited the papers. This is an indication that the research was of-use to practitioners outside the immediate circle involved in the project (Spaapen and van Drooge 2011; Bornmann, Haunschild, and Marx 2016). We identified 20 peer reviewed publications that associated with these projects (as of June 2019) that had been cited in 28 government reports, plans, or other policy-related documents.

As with most questions regarding research impacts, baseline data regarding levels of research use is poor or non-existent. One point of comparison for this bibliometric analysis is Bornmann et al. (2016), who found – albeit in a very preliminary and somewhat constrained analysis - that only 1.2% of climate change publications have mentions in policy documents. In this study, we found that 37% have been cited in agency documents of some type. Although the Bornmann et al. (2016) study is helpful

[2] All project data is required to be posted on Sciencebase. We made efforts to determine whether users were downloading these datasets from Sciencebase, but were unable to confirm specific uses due to the configuration of Sciencebase analytics.

for comparison, a key difference between this assessment and that study is that study looked at research cited in national-level policy documents and did not have access to regional-scale documents. Additionally, the SW and NW CASC research is more regionally focused, which often increases its usability for decision making (Parris et al. 2016).

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Appendix B

Revised Evaluative Framework for CASC-Funded Projects

Project Phase	Evaluative Questions
INPUTS[3]	What inputs that contribute to collaborative research efforts are included in this project?
	• Research team with expertise in collaborative research.
	• Detailed engagement plan included in proposal.
	• Resources (including salary for researchers and practitioners) allocated to engagement activities.
	• Existing partnership or connection between researchers and practitioners.
PROCESS	How did researchers and practitioners interact during the project? Provide example(s) of all that apply.
	• In-person, project specific-meetings (include number and frequency).
	• Meetings coinciding with other events (number and title).
	• Joint fieldwork
	• End-of—project meeting or workshop to share results.
	• Telephone calls and/or videoconferences (approximate number and frequency).
	• Email (approximate number and frequency).
	• Other
	How and when did practitioners contribute to the research? Provide example(s) of all that apply.
	• Defining problem
	• Developing research questions
	• Developing research methods
	• Data collection (joint)
	• Logistical support
	• Contributed data
	• Data analysis
	• Interpretation/review of findings
	• Disseminating findings
OUTCOMES	Were both sets of participants generally satisfied with their level of engagement?
	• Yes. Describe what made it satisfactory
	• Somewhat. Describe what participant would change to make it satisfactory.
	• No. Describe what participant believed hindered engagement.
OUTPUTS	List type and quantity of outputs. Include citations or hyperlinks.

[3] Ideally, all inputs will be considered during the review of the proposal prior to the project being recommended for funding. However, we include them here to provide a complete overview of the factors considered in the framework.

	• Peer-reviewed publications
	• Reports tailored to practitioners
	• Models or data sets
	• Outreach materials tailored to public audience
IMPACTS	What changed because of this project? Include evidence or examples of change.
	• Instrumental – changes to plans, decisions, practices, actions, or policies.
	• Conceptual – changes in knowledge, awareness.
	• Capacity – changes to skills, expertise, or institutional data resources
	• Connectivity – changes to the number and quality of relationships and network connections
	• Attitudes – changes in participants' attitudes toward the process of engaged research
	• Possible future changes – specific examples of anticipated future changes or uses of research findings
	Who changed because of this project?
	• Policy-makers
	• Practitioners
	• Communities
	• Researchers
	• Others

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