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Perspective

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Practical tips to establish an actionable science portfolio for climate adaptation

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Abstract

The delivery of climate adaptation science products and services to inform resource management decisions—otherwise known as actionable climate adaptation science—is the primary driver and intended outcome of the science portfolios administered within the Department of the Interior's Climate Adaptation Science Center (CASC) network in the USA. This commitment hinges on the essential requirement that natural and cultural resource managers (science users) and scientists (science producers) work in unison with one another. This partnership may be illustrated by the conventional demand and supply relationship, where resource managers create the demand term by explicitly describing *a priori* top decisions or priority actions concerning the natural or cultural resources they administer, and scientists supply relevant research products and services. But an ideal interaction of users and producers is not trivial and presents challenges in the process of establishing an actionable science portfolio. A few practical suggestions are presented here to set up a productive dialogue between resource managers and scientists, and broker that conversation as they work side-by-side toward agreed-upon common objectives. These useful tips stem from working towards the goal of establishing actionable science portfolios within the CASC network and may prove valuable to similar entities committed to delivering climate adaptation science to address resource management concerns.

Key words: actionable climate science; natural resource management; manager-scientist engagement; co-production of science; US DOI Climate Adaptation Science Centers.

1. Introduction

The delivery of climate adaptation science to inform the decision-making process of natural and cultural resource management agencies and tribes across the USA was a primary driver leading to the establishment of the Climate Adaptation Science Center (CASC) network[1] by the Department of the Interior. The enabling policy required that "*management decisions made in response to climate change impacts must be informed by science and require that scientists work in tandem with those managers who are confronting climate change impacts and evaluating options to respond to such impacts*" (DOI, 2009). The deliberate directive of dedicating climate adaptation science capital to informing management decisions, and the instruction for scientists and managers to work in unison with one another, have since become bedrock principles in the administration of the science portfolios throughout the entire CASC network.

In recent years, a more diverse audience, tighter budgets, and a growing awareness of the effects of changing climate conditions on natural and cultural resources have increased the urgency to identify pressing resource management decisions that may benefit from robust science contributions (Melillo et al., 2014). This recognition has catapulted the concept of *actionable science* as an effort to help focus scientific climate research toward addressing specific resource management questions (Dilling and Lemos, 2011; ACCCNRS, 2015; Meadow et al., 2015). In its most basic expression, the architecture of an actionable climate science portfolio rests on three fundamental pillars that mimic the configuration of a demand and supply relationship more familiar to those conversant in economics and market theory (Sarewitz and Pielke, 2007). The first pillar is an *a priori* explicit articulation of a climate-sensitive management priority or decision point related to a cultural or natural resource of interest (NRC, 2009). This expression by cultural and natural resource managers, administrators, or decision-makers (henceforth managers) represents the demand function that sets the stage and provides context for the contribution of science to decision-making. Simply put, if the decision-maker fails to clearly articulate the

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impending management decision of interest, then the scientist's likelihood of being able to supply relevant scientific products decreases considerably. The second pillar embodies the supply function: a suitable research agenda and ensuing products and services that the scientific community proposes to best inform the decision-making process. Within a publicly-funded program, the sequential arrangement of these two functions is imperative, for managers' clear expression of their top decisions or planning actions is a prerequisite to guide and inspire scientific activity that delivers the necessary information and products. The third pillar symbolizes the 'negotiation' that ensues between managers and scientists to understand the complexities and conditions of their demand and supply transaction and to fine-tune the terms of their contractual arrangement. Through an iterative exchange, science users and producers jointly explore the precise objectives they wish to achieve, refine the context of the management priority of interest (including, e.g., identifying the main user audience, temporal and spatial scales in effect, specificity, delivery preferences, etc.), and understand the power and limitations of the anticipated science products and services (e.g. uncertainty levels, assumptions, technical and methodological considerations, transferability, and translation assistance).

This conceptual demand and supply relationship sets the stage for an early association between a community of science producers (scientists) and another one of science users (managers) working together on a common problem from the very beginning. This association—or co-production—between science producers and science users has been heralded as the most effective approach to minimize the 'gap' between science producers and users and to maximize the likelihood for science to effectively inform management policies. Multiple scholars analyzed institutional structures and activities intended to support the co-production of knowledge (e.g. convening, translation, collaboration, and mediation) and their relevance in the production of outputs that are regarded as salient, legitimate, credible, timely, and accurate by the user community (Jasanoff and Wynne, 1998; Lemos and Morehouse, 2005; Cash et al., 2006; Roux et al., 2006; NRC, 2009; Meadow et al., 2015; Beier et al., 2016; Moser 2016).

Despite the intuitive logic and anticipated benefits associated with the notion of a co-produced actionable climate science portfolio, bringing this process to fruition is not trivial. Several tangible and intangible challenges may become evident only when shifting from theory to implementation, some of them capable of sabotaging the best of efforts. The suggestions presented here contribute to the existing body of work intended to maintain the dialogue between managers and scientists, and to encourage them to work side-by-side toward agreed upon common objectives (e.g. NRC, 2009; Beier et al., 2016; Moser 2016). These useful tips stem from working towards the goal of establishing actionable climate science portfolios within the CASC network since its inception, and may prove valuable to similar entities committed to delivering climate adaptation science to address resource management concerns.

2. Diagnosis at the ground level

The pursuit of actionable climate adaptation science typically runs into early pervasive difficulties. The collective practical experience emerging from the administration of the actionable science portfolios at the CASC network identifies several issues that deserve attention. The first issue is one of identity. Who are considered to be science users? Who are the science producers? This can sometimes be a difficult—or perhaps artificial—dichotomy and does not reflect the complex reality that many managers are actively involved in the generation of new science information, whereas others have no interest or involvement in the scientific process at all. Similarly, many scientists have real-world experience in the management of natural resources, but others only recognize pure, basic science with no discernable practical application, solely for the purpose of furthering intellectual knowledge. These extremes among managers and scientists outline broad categories that accommodate many individuals with a diversity of talents, interests, and responsibilities. Knowing who-is-who during actionable science transactions helps clarify who is supposed to *demand* science products and who is supposed to *supply* them.

The second issue that merits attention has to do with managers, representing federal, state, indigenous, and other natural resource organizations, who fail to clearly articulate the top climate-sensitive management priorities or decision points concerning the natural and cultural resources they administer. Over the years, a common response encountered across the CASC network when asking managers to 'state their *management priorities*' (i.e. articulate a demand statement), is one that may begin with 'my *science needs* are…'. This quick pivot continues with a long recitation of products (i.e. elements that belong to the supply column) that managers think they need from scientists (such as studies, data, projections, models, assessments, adaptive technology innovations, etc.), but almost invariably without an explicit description of their intended management application. Because these lists of science needs originate from managers, they become—in the absence of careful thought—*management needs*. Suddenly, *management needs* and *science needs* are confounded and effectively become the same thing: both terms focus exclusively on desired science products, and neither one offers a satisfactory response to the original request regarding crucial management priorities that should drive and justify the pursuit of science products. *The inconsistency here is having science users itemize elements they wish to have supplied to them, instead of articulating clear statements of demand*. The recognition of users' (stakeholders', managers', or decision-makers') *needs* as surrogates for their decision context has been the focus of previous analyses that confirm that the actual intended application of what users demand of science is not always intuitive, much less explicitly stated (e.g. Allen et al., 2017; Dilling and Berggren, 2014). The erroneous conflation of the terms *management needs* and *science needs* is far more consequential than a mere semantic preference and makes a tremendous difference in understanding the demand and supply terms in the context of the science-manager partnership. Certainly, the absence of clearly stated resource management priorities that could capitalize on certain scientific information or products severely compromises the very foundation of actionable science.

The third observation encountered on occasion under the umbrella of the CASC network science program, corresponds to scientists who expect to secure funding for their proposed work regardless of its management relevance (e.g. NRC, 2009). The vacuum generated when managers fail to articulate their priorities does not remain vacant for long. The creative minds within the scientific community do not hesitate to fill those voids in the desired management demand narrative and quickly advance a few elegant research ideas or offer multiple sophisticated scientific and technological products (e.g. experimental analyses, modeling approaches, Geographic Information System (GIS) layers, and website applications), all while highlighting their best guess at potential management applications and presumed benefits to inform decisions. This modality emerges from science providers who (1) are more

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interested in the pursuit of intellectually attractive endeavors than in identifying applications for their science products in response to priorities stated by managers, or (2) who fail to find the appropriate managers they should be working together with, or (3) who prefer to align their efforts behind a priority they created (i.e. not a priority identified by a manager) and believe to be of management significance. In these cases, the delivery of science products and services is unidirectional and indifferent to who may use them, when, where, or for what purpose. In the specialized literature, this approach to research is illustrated by a 'loading dock' metaphor, in which science is pushed on the loading dock outside the building for pick-up, regardless of the priorities and realities of the end-user community (Cash et al., 2006; Karlin et al., 2017). The inconsistency in this case is having science producers manufacture a demand statement for the products they supply. To some, this pattern offers an acceptable alternative to actionable science by sufficiently conveying the *appearance* of management relevance. But even if serendipitous events eventually lead to the use of some of these self-motivated scientific products in a management context, the anticipated benefits and efficiencies of the co-production process will have not materialized.

3. How does one set the stage for true actionable climate science?

Actionable climate adaptation science represents a critical vector through which the CASC network fulfills its core function of connecting the regional scientific capacity with the priorities of corresponding resource management agencies and indigenous communities in the United States. Since the network's creation, our approach invites scientists and resource managers to work side-by-side with one another. To make this co-production dialogue a reality, the centers within the CASC network selectively exercise or modify several pragmatic approaches according to their configuration, capacity, history, and other regional factors. This list of practical tips is not meant to be exhaustive, but may prove useful to other science administration programs:

3.1 Create opportunities to discuss actionable science at multiple levels

For boundary organizations like CASCs that straddle the scientific and resource management domains, it is important to recognize any and all relevant dimensions where the conversation about actionable climate science may take place. CASCs are more directly involved with demand for, and supply of, actionable climate science as it emerges both at the project and regional scales (DeCrappeo et al., 2018). At the project level, the parties involved include funded Principal Investigators (science providers) and individual on-the-ground resource managers (science users) working jointly on a specific research project. These one-on-one partnerships are a common denominator for every research project funded through the CASC network science programs. At the regional scale, the discussion may involve advisory bodies or ad-hoc panels, such as the Stakeholder Advisory Committee (SAC) or the Science Advisory Panel (SAP), that provide high-level advice to CASC leadership. The former convenes representatives from federal, state, and indigenous organizations that help identify priority climate adaptation issues concerning the management of natural and cultural resources in their region. The latter brings together recognized scientific leaders from academic institutions and other research centers in the region, capable of identifying the most relevant climate adaptation scientific information and products of use to managers. Bodies like the SAC and the SAP jointly deliberate on the salient regional management and science components of a long-term actionable science agenda that may be used by the pertinent CASC as a blueprint for priority research investments over time. At either scale—project or regional—the terms of demand (management priorities) and supply (anticipated scientific products and services) need to be clearly stipulated. As an illustration, consider the case of a fish husbandry program under scrutiny: a top agency administrator dealing with Congressional demands, budget cuts, and agency reorganizations may have a completely different set of questions, priorities, and regard for science products than the on-site hatchery manager who works for the very same agency and hopes to highlight the merits of the facility he/she operates.

3.2 Recognize who is involved in actionable science transactions

Continuing with the analogy of supply and demand, an actionable climate science portfolio may be likened to a marketplace environment that invites the transaction of commodities (scientific products or services) between science producers and science users. Science producers include experts in different scientific disciplines and Indigenous knowledge systems (Alexander et al., 2011) capable of systematically observing, understanding, or predicting the physical, natural, and social realms. Science producers not only vary in their discipline or field of expertise, but their orientation also ranges from purely basic scholarly interests to full application of science to practical issues. This orientation has strong implications on the degree of interest in entering a co-production relationship. Likewise, science users also include a broad array of expertise and interests. Stakeholders, bureaucrats, administrators, decision-makers, community planners, or resource managers are some of the popular terms used to identify the science user community. In general terms, science users include experts in environmental, social, economic, or political processes, administrative procedures, and those responsible for planning, managing, and making climate-sensitive decisions in different sectors (Dilling and Berggren 2014). Their degree of scientific literacy—that is their understanding of the power and limitations of science and how science products and services may be incorporated in the planning and implementation of decisions—ranges broadly according to their educational background, prior experience, and professional responsibilities. Having a clear sense of who represents the science user and science producer communities is an important step toward brokering productive transactions between the two.

3.3 Encourage managers and scientists to adhere to their respective roles

The dialogue proposed under an actionable science context requires both managers' and scientists' participation. Also necessary is a steady discipline to facilitate this exchange. As stated earlier, some scientists have a very good understanding of resource management issues much like some managers display a solid grasp on elements of the scientific enterprise. Often, this conversational fluency in each other's professional field, in fact, facilitates the dialogue considerably. But at the CASC network the instructions to both parties are unyielding: science users should articulate the demand terms, and science producers should describe the products they supply. There is no one better than managers to articulate the priority concerns for the resources they administer, thus legitimizing their demand for

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science products. Correspondingly, the voice of scientists helps us better understand the power, assumptions, limitations, and uncertainties behind the scientific products they may be able to supply. Moderating this growing conversation requires one to remain vigilant and redirect any manager or scientist that may stray into the other's less familiar terrain.

3.4 Watch what happens when the word 'need' is not allowed

Phrases such as 'needs assessment' or 'statement of needs' are prevalent terms of art in resource management contexts, leading to the transposition—and potential confusion—described earlier. Staying away from using terms like *management needs* and *science needs* during communications with regional stakeholders and scientists is an efficient way to overcome this challenge. Instead, some CASC network staff have adopted alternate terminology that more categorically describes what is of interest. For instance, one option is to consistently refer to *management priorities* when searching for resource management drivers associated with important decisions. Similarly, one may refer to *science opportunities* to describe elements of the scientific enterprise that may be considered in the decision-making process. Other terms would be equally acceptable, so long as they stay clear of the word *need* entirely. By following this convention, it is possible to eliminate the instances for confusion or substitution of terms in the interaction with regional managers and scientists. Once again, the first step toward securing well-defined management priorities and useful lists of scientific products and services is to recognize that they are entirely different from one another.

3.5 Coach early and reap great benefits later

Coaching scientists early in the research proposal development phase may yield rewarding dividends during later phases of screening and selection of quality research proposals. The annual funding cycles sponsored by CASCs invite and consider only research proposals that clearly offer actionable climate science products. The selection criteria assign heavy scores to proposals that adequately describe the management priority expected to benefit from the proposed research and identify the manager that will more closely interact with the study team throughout the life of the project. During these early stages in the development of a research idea, one strategy is to encourage scientists to 'jump on the time machine' and travel to a future time when their project has been completed. Once there, the questions they need to ask themselves are 'Who are the resource managers that could possibly benefit from my recent findings and products?' and 'What are the decisions that my recent scientific products have helped inform?' With answers to those questions in hand, the exercise concludes when scientists return to the present day and start communicating with those resource managers without delay to begin framing an actionable research proposal.

3.6 Make letters of support count

While some letters of support for a particular project proposal can be elaborate and thoughtful, it is not uncommon to receive others that consist in perfunctory correspondence containing a robot-like support for the proposed study and the consequent request for funding. In many cases, the intervention by the signer is rather ephemeral and disappears as soon as the proposal is selected for funding. The guidance for research proposal preparation developed by the CASC network requires the inclusion of letters of support that originate from, and are signed by, a resource manager, and contain the following elements: (1) The manager's brief description of the anticipated research products, (2) An explicit example indicating the intended use of the anticipated scientific results in a concrete management scenario, and (3) A commitment from the signing manager to stay involved with the research team through the life of the project. Letters of support for the funding of research proposals may turn into essential records, because they identify the best positioned resource managers who can later describe whether and how science products resulting from CASC-sponsored projects helped inform management decisions.

3.7 The best referral comes from a satisfied customer

The worth and continuity of an actionable science portfolio administered by a publicly funded undertaking such as the CASC network hinges on the level of satisfaction your customers (science users) experience regarding your brand, program, and products. There is no better opportunity to promote high satisfaction and secure vibrant enthusiasm by science users than to engage them fully in the assembly and maintenance of the very science portfolio built to address their own management priorities. The proposed engagement of resource managers properly exempt from any conflict of interest may include contributions to the drafting of requests for proposals, to participating in the review and scoring of science proposals, to witnessing firsthand how the final selection of projects and adjudication is decided. This call-to-action on science users far exceeds their sporadic attendance to meetings or their response to occasional consultations. The intrinsic benefits of this participatory inclusion provide a powerful referral boost in which science users disseminate positive feedback about your science portfolio and products with others within their own organizations, outside professional networks, Administration officials, Congressional delegations, and the general public.

3.8 A picture is worth a thousand words

When actionable climate science deliverables are made available to the user community, it is important to memorialize the existence of such products, to recognize the scientists and managers that collaborated in the effort, and to specify the types of applications intended for those products. Better than writing about what actionable science is and is not, highlighting successful actionable science projects through concrete examples may be the most efficient way to illustrate what actionable science is all about and how it gets done, paving the road for future similar endeavors. This communication effort is a central service provided by the CASC network by showcasing sponsored science achievements and their actual applications through oral presentations as well as printed products (e.g. newsletters, fact sheets, and annual reports), electronic platforms (e.g. websites, webinars, and story maps), and social media networks. The target audience includes prospective scientists that may consider submitting project proposals in the future, resource managers that seek scientific advice or products, agency administrators and Congressional staff that oversee funding levels and determine program continuity, and the public at large who deserves reassurances about the prudent disposition of their tax contributions.

3.9 Assume nothing, question everything

Advertising and otherwise bolstering the quality of the product and service mix emerging from an actionable climate science portfolio requires to routinely evaluate whether such image matches the reality of the operation. An objective evaluation module is an indispensable tool to help entities—like CASCs—that fund science and

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provide service to resource managers, gauge the degree of 'actionability' behind their science portfolios. Within the CASC Network, the general preference is to take an agnostic approach that periodically assesses how well each center's long-term Science Agenda has been implemented, the level of success in bringing managers and scientists together, and to what extent CASC-sponsored products help inform management decisions (e.g. Pullin et al., 2004; NRC, 2009; Dilling and Lemos, 2011; Wall et al., 2017b). Through surveys and questionnaires, stakeholders and science users are asked questions such as 'Is the CASC under consideration actually delivering actionable climate science?', 'Are management organizations using it?', and/or 'Are management decisions better informed because of the science products and services it sponsors?'. Responses to questions like these allow us to consider any necessary refinements and corrective actions to the demand and supply terms of the equation embedded in our actionable science program.

3.10 Find the extra gear

The success of actionable science (i.e. science becomes incorporated into a concrete resource management context) requires more than just the user-producer dyad or the sterile transfer of knowledge and science products. It involves and invites a much richer and nuanced dialogue between resource manager and researcher communities where they both can exchange their respective worldviews and perspectives on the sociological, environmental, institutional, and political contexts in front of them. Recent scholarly contributions by Enquist et al. (2017) and Wall et al. (2017a), for example, provide in-depth assessments of the numerous tangible and intangible factors that frame this deeper translational approach to pave the way between scientific findings and resource management action. This notion parallels the more familiar role of extension activities and advisory services, long recognized in the rural sector as a key vehicle to provide farmers with research-based information, experiential learning approaches, management skills, and technology transfer. Ultimately, the benefits emerge in the form of increased relevancy, credibility, and legitimacy of science products that can inform resource management decisions. Laursen et al. (2018), for instance, discuss how fostering engagement and interpersonal relationships within the local knowledge networks that users intuitively build in their search for useful information help integrate, establish, and strengthen behavioral patterns that underpin the transfer of climate science and products into real-world decision-making. Investing in extension or translational efforts may have a transformative effect regarding future research programs and initiatives, where deeper understanding, trust, reflection and awareness both by science practitioners and beneficiaries could contribute significantly to improving decisions on climate adaptation and resilience.

4. Conclusion

The creation and administration of an actionable climate science portfolio are not straightforward functions. There are multiple actors, processes, and barriers that may undermine the best of intentions, rendering a science portfolio—or portions of it—less than optimal for effective resource management. Sometimes the detection of these shortcomings is not immediate or self-evident. Bringing scientists and resource managers together behind a common actionable climate science effort presents CASCs and other similar organizations with a unique opportunity—and responsibility—to find an adequate balance between the demand for, and the supply of, quality climate science within their respective communities. These communities will capitalize on regional leadership when CASCs and others maximize their organizational competencies, pay close attention to detail, and constantly explore innovative routes to address unmet needs and deliver useful content to their audience.

Note

1. The network includes a National Center and eight Regional Centers, previously known as Climate Science Centers (CSCs), established in 2009.

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