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Adapting science to a warming world

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ABSTRACT

Climate change is complicating the variables that Alaskans consider when planning for the future. Communities, agencies and other entities have begun to grapple with both the information that they need to adapt to a changing climate and how the processes and practices of science should change to make science more useful. We reviewed sixty-three documents that expressed practical research needs related to climate change in Alaska. Documents nearly unanimously expressed that science, as it is currently practiced, is inadequate to meet the challenges of climate change. They call for processes that are more transparent, collaborative, and accessible. They recommend changed practices including maintaining accessible data-sharing archives, building networks for knowledge sharing, and creating place-based long-term partnerships with communities. They advocate integrating local knowledge, but infrequently address the complexities of how this is best accomplished. They also suggest the need for improved training in interdisciplinary research and changes in the incentive structure of research institutions. This review complements the climate-change literature by providing concrete suggestions about how to increase the utility of science from a region that is experiencing some of the most dramatic climatic change on the planet.

1. Introduction

It is difficult to ignore climate change in Alaska. Since 1949, average annual statewide temperature has increased 1.7 °C with the highest increases in the winter (Stafford et al., 2000). From melting glaciers to coastline erosion and from permafrost thaw to dangerous ice conditions, Alaskans can see and feel the tangible impacts of a changing climate. Many indigenous rural communities are threatened by flooding and erosion, as well as changes to traditional subsistence practices due to changes in fire regime, access, and distribution of food resources (United States General Accounting Office, 2003; Kofinas et al., 2010; Cochran et al., 2013). Many sectors, including industry, public works, public health, and transportation are also impacted by changing conditions (Markon et al., 2012). Alaskans face the tangible impacts of climate change, but often lack the long-term data sets and expertise to assess and understand changes in climate, hydrology, and ecology. In the past decade tribal, municipal and state governments, state and federal agencies, and other entities across Alaska have begun to identify not only what they need to know to help them adapt to changing conditions but also how the process of science itself should adapt to meet increasingly complex information needs. We analyzed sixty-three climate information and science needs assessments specific to Alaska. Our objective was to understand what stakeholders suggest about how the process and practices of climate science could change to improve informed response.

The voices of these Alaskans are part of a larger dialog about how science should be conducted and how it can better inform decision-making. Scientific and research institutions have traditionally operated under the assumption that increased information would lead to better decisions (Feldman and Ingram, 2009; Cash et al., 2006), but this focus on information is often less effective than focusing on the actors and institutions that may require and utilize this knowledge (Mitchell et al., 2006). For knowledge to be used in practice, it must be salient, credible and legitimate (Cash et al., 2002). Salience is the relevance of information for decision-making, credibility addresses whether the knowledge produced is trustworthy and believable, and legitimacy refers to whether the resulting knowledge is judged to be fair and unbiased. Information from science can be rejected or ignored if one of these attributes is not met. Information may fail to be salient because it fails to match the temporal or spatial scale of the decision-space, or it may fail to address the complexity of the issue at hand (Jones et al., 1999). Despite peer review and rigorous methodology, research may fail the test of credibility if

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research results contradict local experience (Wynne, 1992). Information may be seen as illegitimate if the processes or application of knowledge are seen as unfair.

Researchers have debated how to increase the salience, credibility, and legitimacy of science to make it more useful in practice. Post-normal science has emerged as a way to actively engage citizens in finding solutions to their problems (Funtowicz and Ravetz, 1993). Resilience scholars have encouraged attention to the interactions between social and ecological systems (Folke, 2006). Scholars have bemoaned the inadequacy of current structures of knowledge production and dissemination, calling for a more collaborative and iterative dialog to improve societies awareness of and ability to adapt effectively to climate change (Dilling and Lemos, 2011). Common suggestions to improve the relevance of science include co-production of knowledge, increased use of inter- and transdisciplinary methods, integration of different forms of knowledge, user-driven science, and boundary organizations, or entities designed to increase collaboration across traditional boundaries (Berkes, 2009; Guston, 1999; Hulme, 2010; Pohl, 2008). Pettigrew et al. (2003) has suggested that research that helps to deliver both "what is" and "how to" knowledge may be more relevant than research that only focuses on one or the other. These suggestions have come from the research community and while some directly engage the stakeholders and decision-makers, many are generated strictly from expert knowledge. This project builds on existing literature by providing regionally grounded stakeholder suggestions for ways that science can provide more useful and relevant information to facilitate climate adaptation.

These reflections point to a departure from scientific norms and suggest a need to transform scientific approach, outcomes, and methods. The suggestions offered in this review may be challenging to implement because of current institutional structures. Institutions embody the "rules of the game" (Young, 2002), and are often fairly conservative or difficult to change. Resistance can be attributed to path dependence, or the way prior decisions constrain and shape current decisions (Pierson, 2000). Systems of knowledge creation and governance tend to become more rigid over time, leading to better system control, but decreasing system resilience (Holling and Meffe, 1996). Science is not just a method of gaining knowledge, but a series of institutions and organizations that structure the way scientific knowledge is produced. While there are signs that a transformation has already begun, implementing the suggestions identified in this review will require significant restructuring of scientific institutions, including new structures for data sharing, more emphasis on science translation, and revised scientific incentive structures.

2. Materials and methods

We analyzed sixty-three documents that expressed the climate change science and information needs of a diversity of stakeholders in Alaska. Criterion for document selection were that the document (a) is related to climate change, (b) addressed concerns of stakeholders in Alaska and, (c) focused on answering questions to inform practical and policy decision-making (Clark, 2007). We included documents that were created for agencies, tribes, communities or governmental entities, and removed those that were created for research institutions (Table A.1, Column 5). We identified sixty-three documents through web searches and confirmed the completeness of our sample through conversations with local experts in different sectors. Documents included needs assessments (35%), summaries of climate change impacts (23%), strategies to deal with climate change impacts (12%), presentations about climate change (12%) and letters, notes and other types of documents (17%). All of the documents were created between 1998 and 2012, with over half created since 2010 (Fig. 1). We completed document identification in March 2012 so more recently created documents are not included in this review.

Documents addressed a range of research needs (Fig. 2). Assessments were initiated by research institutions (25%), federal agencies (23%), state government (15%), non-profit groups (14%), state agencies (12%), local governments (5%), and others (5%). Assessments created by research institutions were only included if they conducted the needs assessment to inform practical decision-making and policy. Entities served by needs assessments included local and state government (e.g. State of Alaska), federal agencies (e.g. US Forest Service), state agencies (e.g. Alaska Department of Fish and Game) and non-profit organizations (e.g. Center for Ocean Science Educational Excellence). Documents in the review were created using expert knowledge (60%) and workshops (22%). More in-depth participatory assessments using interviews (3%), surveys (3%), and focus groups (2%) were rare. A complete list of documents included in the review and web addresses are included in Appendix A (Table A.1).

We used qualitative content analysis methods to understand what each document articulated about research needs and scientific process and practices. Content analysis is a technique that gathers sections of text related to similar themes, also called coding, to assess thematic patterns across documents (Bernard and Ryan, 2010). We started with a coding list based on prior research (Markon et al., 2012) and then expanded on this list as new themes of interest emerged (Denzin and Lincoln, 2005). The sixty-three needs assessments represented in this report represent over 4000 pages of coded material. Each document had an average of 51 codes

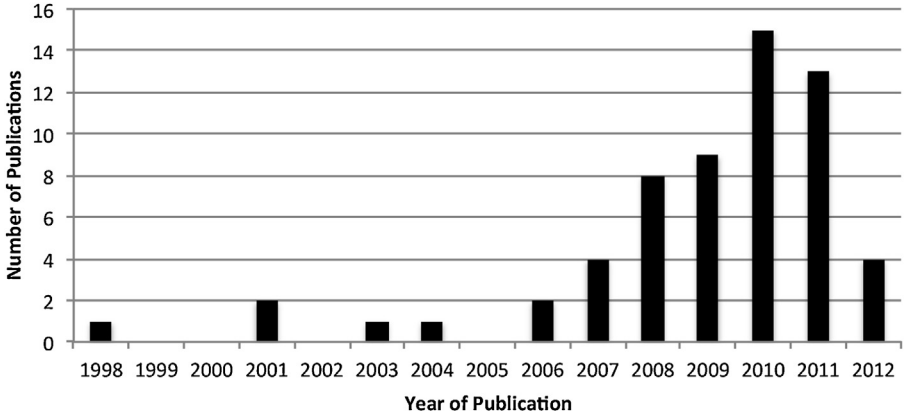

Fig. 1. Number of needs assessment publications per year included in this review (Publications were collected until March 2012).