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Great Basin land managers provide detailed feedback about usefulness of two climate information web applications

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ABSTRACT

Land managers in the Great Basin are working to maintain or restore sagebrush ecosystems as climate change exacerbates existing threats. Web applications delivering climate change and climate impacts information have the potential to assist their efforts. Although many web applications containing climate information currently exist, few have been co-produced with land managers or have incorporated information specifically focused on land managers' needs. Through surveys and interviews, we gathered detailed feedback from federal, state, and tribal sagebrush land managers in the Great Basin on climate information web applications targeting land management. We found that a) managers are searching for weather and climate information they can incorporate into their current management strategies and plans; b) they are willing to be educated on how to find and understand climate related web applications; c) both field and administrative-type managers want data for timescales ranging from seasonal to decadal; d) managers want multiple levels of climate information, from simple summaries, to detailed descriptions accessible through the application; and e) managers are interested in applications that evaluate uncertainty and provide projected climate impacts.

1. Introduction

Climate change impacts have been documented for ecosystems worldwide (Chambers and Pellant, 2008; Grimm et al., 2016; Hansen and Biringer, 2003; Hoegh-Guldberg and Bruno, 2010; Shaver et al., 2000; Walther et al., 2002). In the Great Basin, U.S.A., land managers maintain or restore sagebrush landscapes plagued by invasive grasses, encroaching conifers, changing fire regimes, habitat fragmentation, and urbanization (Connelly et al., 2004; Knick et al., 2003; Miller and Svejcar, 1994; Shultz, 2012; Boyd et al., 2017). Climate change may amplify these threats and add uncertainty around current management strategies (Abatzoglou and Kolden, 2011; Homer et al., 2015; Neilson and Lenihan, 2005). Climate change projections provide managers with information that helps them focus their limited time and resources towards issues that are critical to the landscape they manage. Projections are currently available through multiple interactive, web-based applications (e.g. https://toolkit.climate.gov/tools), but such applications have had low adoption because of access issues, mistrust or misunderstanding of the information, overabundance of possible sites to explore, or limited usefulness because of the scale of information provided (Archie et al., 2012; Bierbaum et al., 2013; Brown and Bachelet, 2017; Dilling et al., 2015; Dilling and Lemos, 2011; Jantarasami and Lawler, 2010; Kemp et al., 2015; Weichselgartner

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and Kasperson, 2010). Considering the broader context of generating usable climate change knowledge, some of these problems have been associated with a lack of co-production between application developers, scientists, and users (Dilling and Berggren, 2015; Dilling and Lemos, 2011; Moss et al., 2013). However, guidance on how to approach co-production in the specific context of web-based applications that provide climate and weather information is limited.

Co-production of knowledge is a growing field of literature that describes the process of domain experts, non-domain experts, and stakeholders collaborating to generate knowledge (Jasanoff, 2004; Lemos and Morehouse, 2005; Lemos et al., 2012; Simpson et al., 2016; Tribbia and Moser, 2008). The co-production model combines two modes of science production defined as "science push" and "demand pull" (Sarewitz and Pielke, 2007; Stokes, 2011). Science push refers to the pursuit of knowledge for the sake of advancing a research objective without thoughtful consideration as to how this knowledge will be applied. Demand pull refers to the pursuit of knowledge to solve a problem with little consideration as to the feasibility and scientific applicability of these solutions (Dilling and Lemos, 2011; Guido et al., 2012; Sarewitz and Pielke, 2007; Stokes, 2011). Under the co-production model, push and pull modes are combined so that research agendas are shaped through an iterative process between knowledge producers and users (Dilling and Lemos, 2011; Guido et al., 2012). Knowledge that is co-developed by producers and users has been proposed as being more tailored to the needs of users compared to knowledge produced under a more traditional research paradigm (Briley et al., 2015; Dilling and Lemos, 2011). While this co-production approach has the promise of addressing many issues associated with communicating and applying climate change knowledge, of particular interest to this study is how web applications that provide weather and climate information are co-developed in a way that is scientifically useful while also providing knowledge that is usable to intended consumers.

Wide-ranging scholarship has considered the presentation of climate-related information, via computer-based visualizations and web portals, to various user-groups. Examples of intended users of this climate information include homeowners (Neset et al., 2016; Glaas et al., 2017), planners and managers (Cerveny et al., 2011; Bishop et al., 2013; Bohman et al., 2015; Guido et al., 2012), and broader audiences with a focus on decision-making (Swart et al., 2017). Previous research has identified the importance of transparency in climate change information in order to generate credibility among users (Dockerty et al., 2005), especially for web-based tools presenting climate information (Glaas et al., 2017). In addition to clearly providing sources of information, being able to choose between climate projections and scenarios is seen as a way to build confidence in the information presented (Moser, 2014), with interactive visualizations of climate impacts on landscapes shown to help users better evaluate management options (Bishop et al., 2013). While there has been substantial research effort in understanding climate information communication through tools and visualizations, to our knowledge, research that examines web-based tools that are designed to assist managers with decisions that include weather and future climate considerations is limited, particularly with regard to conservation or restoration of sagebrush ecosystems.

This paper documents results from the second phase of a multi-stage co-production effort in which the perspectives of sagebrush land managers are elicited in order to more effectively develop web applications. The objective of the overall project is to discover how climate change information generated by climate and climate impact modelers can be packaged most effectively to provide useful and usable information to land managers. In a previously published study summarizing the first phase of this project, Brown and Bachelet (2017) established the need for more tailored web tools specifically designed for sagebrush managers. Usefulness and usability of the climate information were found to be related to factors that include accessibility, scale of information, and background education of the user, similar to themes that have emerged in recent literature (Archie et al., 2012; Dilling et al., 2015; Dilling and Lemos, 2011; Jantarasami and Lawler, 2010; Kemp et al., 2015). In the second phase of our project, we built upon these early results using participant feedback to identify the specific needs of sagebrush land managers and conservation planners as part of our on-going co-production effort to develop and/or refine web applications that support adaptive management strategies. Our objective in the third and final phase of this project, and our ultimate measure of effectiveness, will be to elicit manager perspectives about how our tools either are, or are not, being used to implement adaptive strategies for addressing the many stresses that affect sagebrush ecosystems in the context of a changing climate.

2. Methods

2.1. General approach

Climate scientists and web developers at the Conservation Biology Institute (CBI), located in Corvallis, Oregon, have actively collaborated with potential users on a variety of web-based applications in a multi-phase project focusing on sagebrush dominated landscapes. This first phase focused on existing climate-related websites, and assessed, through interviews with managers, the usefulness of this information to Bureau of Land Management (BLM) sagebrush land managers in Oregon and Idaho (Brown and Bachelet 2017). The results from this first phase were then applied by developers who updated an existing CBI climate application, the DRECP Climate Console (http://drecp.consbio.webfactional.com/climate). This application, originally created for an unrelated project, was upgraded to include more graphics, additional climate variables, different spatial and temporal scales, and improved terminology, providing more relevant information to managers and planners (Bachelet et al., 2017). The updated Climate Console was designed to provide sagebrush managers with a site where Coupled Model Intercomparison Project Phase 5 (CMIP5) climate projections, regional intactness, and soil sensitivity were available for a series of reporting units relevant specifically to sagebrush extent and grouse range. Addressing the feedback from the first phase of this project, the application allows users to display short-term National Oceanic and Atmospheric Administration (NOAA) forecasts (http://www.cpc.ncep.noaa.gov/) as well as a set of relevant reference layers including the resilience-resistance map widely used for rapid assessment across rangelands (Maestas et al.,