Journal of Environmental Management 169 (2016) 313–318

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Capturing subregional variability in regional-scale climate change vulnerability assessments of natural resources

Polly C. Buotte [a, b, *], David L. Peterson [c], Kevin S. McKelvey [d], Jeffrey A. Hicke [b]

[a] University of Idaho, Environmental Science Program, Moscow, ID, 83844, USA
[b] University of Idaho, Department of Geography, 875 Perimeter Drive MS 3021, Moscow, ID, 83844, USA
[c] U.S. Forest Service Pacific Northwest Research Station, 400 N 34th St. Suite 201, Seattle, WA 98103, USA
[d] U.S. Forest Service, Rocky Mountain Research Station, 800 E. Beckwith, Missoula, MT 59801, USA

ARTICLE INFO

Article history:
Received 6 September 2015
Received in revised form
10 December 2015
Accepted 12 December 2015
Available online 19 January 2016

Keywords:
Climate change
Vulnerability assessments
Geographic variability
Natural resources

ABSTRACT

Natural resource vulnerability to climate change can depend on the climatology and ecological conditions at a particular site. Here we present a conceptual framework for incorporating spatial variability in natural resource vulnerability to climate change in a regional-scale assessment. The framework was implemented in the first regional-scale vulnerability assessment conducted by the US Forest Service. During this assessment, five subregional workshops were held to capture variability in vulnerability and to develop adaptation tactics. At each workshop, participants answered a questionnaire to: 1) identify species, resources, or other information missing from the regional assessment, and 2) describe subregional vulnerability to climate change. Workshop participants divided into six resource groups; here we focus on wildlife resources. Participants identified information missing from the regional assessment and multiple instances of subregional variability in climate change vulnerability. We provide recommendations for improving the process of capturing subregional variability in a regional vulnerability assessment. We propose a revised conceptual framework structured around pathways of climate influence, each with separate rankings for exposure, sensitivity, and adaptive capacity. These revisions allow for a quantitative ranking of species, pathways, exposure, sensitivity, and adaptive capacity across subregions. Rankings can be used to direct the development and implementation of future regional research and monitoring programs. The revised conceptual framework is equally applicable as a stand-alone model for assessing climate change vulnerability and as a nested model within a regional assessment for capturing subregional variability in vulnerability.

1. Introduction

Global mean annual temperature has increased by 0.8 °C since 1880 (Walsh et al., 2014), and future warming is almost certain (IPCC, 2013). Although historical precipitation trends vary spatially (IPCC, 2013), declines in regional streamflows have been well documented (Fu et al., 2010; Luce and Holden, 2009; Rood et al., 2005). Understanding how these temperature and precipitation changes will affect natural resources, and developing management plans that address these changes, is a primary focus of federal natural resource agencies in the United States (National Park Service, 2010; USDA Forest Service, 2008). Developing such management plans requires projecting future climate conditions and understanding how climate can influence natural resources. Climate change vulnerability assessments (CCVAs) provide a framework for achieving this understanding.

For the United States Forest Service (USFS), CCVAs fulfill several purposes. They provide a framework for synthesizing projections of future climate conditions, assessing known sensitivities of species or resources to direct and indirect effects of climate change, developing potential management strategies and tactics for adapting to climate change, and monitoring the outcomes of those actions (Peterson et al., 2011). CCVAs can also help ensure that stated agency or organizational goals can continue to be met under changing climate conditions (Julius et al., 2008), and that they fulfill

* Corresponding author. University of Idaho, Department of Geography, 875 Perimeter Drive MS 3021, Moscow, ID, 83844, USA.
E-mail addresses: pbuotte@uidaho.edu (P.C. Buotte), peterson@fs.fed.us (D.L. Peterson), kmckelvey@fs.fed.us (K.S. McKelvey), jhicke@uidaho.edu (J.A. Hicke).

http://dx.doi.org/10.1016/j.jenvman.2015.12.017
0301-4797/

federally mandated requirements to address climate change impacts within the agency (USDA Forest Service, 2008).

Across the United States, the USFS has to date conducted multiple CCVAs (EcoAdapt, 2014; Halofsky et al., 2011; Raymond et al., 2014; Swanston et al., 2011). These assessments focused on relatively small regions and included one to four National Forests or National Parks (e.g., Olympic National Forest and Olympic National Park, WA (Halofsky et al., 2011); northern Wisconsin (Swanston et al., 2011); the Nez Perce-Clearwater National Forest, ID (EcoAdapt, 2014); and the North Cascades Range, WA (Raymond et al., 2014)).

An alternative to multiple CCVAs, each focused on a small area, is a regional CCVA, which can include multiple land management agencies and cover many management units. Conducting regional-scale CCVAs offers several advantages. A regional CCVA may provide a better match to the scale of species distributions and the scale at which ecological processes (e.g. dispersal) operate. Another advantage is the increased potential for collaboration across administrative boundaries, which rarely have ecological relevance. Collaborating across boundaries allows the development of local management options that are coordinated over a larger region (Joyce et al., 2008; Littell et al., 2010). For example, from a local perspective a species undergoing a range shift may look like extirpation, but from a regional perspective such change can be seen as a range expansion and an opportunity for collaboration (Stephenson and Millar, 2012). Finally, organizing and conducting one regional CCVA may be more efficient than conducting multiple smaller CCVAs.

Regional CCVAs can provide a starting point for developing a portfolio of management strategies coordinated across ecological and administrative boundaries. Comparing and contrasting climate change vulnerability across subregions can aid in developing adaptive monitoring and research programs (Lindenmayer and Likens, 2009) based on hypotheses describing those vulnerabilities (Nichols and Williams, 2006). Thus, regional CCVAs offer significant advantages for large land management agencies such as the USFS.

However, there are important challenges of selecting appropriate species or resources and capturing subregional variability in vulnerability in regional CCVAs that are not present in CCVAs of smaller regions. Because of their extent, regional CCVAs can span a range of environments and habitats, include more species and populations, and involve potentially differing management objectives and priorities. These issues may lead to concerns about the quality and usefulness of regional CCVAs, yet to date no research has evaluated ways to address these concerns. We are unaware of an assessment that attempted to cover a large, climatically and ecologically diverse area, provide a summary of natural resource vulnerability across the region as a whole, and incorporate variability in natural resource vulnerability with subregions.

In this paper, we present a framework for capturing subregional variability in climate change vulnerability in a regional CCVA. First, we describe the framework as implemented in the first regional CCVA conducted by the USFS and partner agencies and organizations. Second, we summarize the results of implementing the framework for wildlife resources, evaluate the evidence for subregional variability in vulnerability to climate change, and evaluate the ability of our framework to characterize subregional variability. Finally, we recommend how the process can be improved. Although we focus on wildlife vulnerability, we provide examples of how this approach can be applied to other natural resources as well.

2. Methods

2.1. The regional CCVA

The Northern Rockies Adaptation Partnership (NRAP) was the first regional CCVA led by the USFS (http://adaptationpartners.org/nrap). The two primary objectives of NRAP were to synthesize the best available scientific information to assess climate change vulnerability, and develop adaption options. The NRAP geographic area covers 15 national forests and three national parks in the USFS Northern Region, which includes the northern panhandle portion of Idaho, all of Montana, portions of North and South Dakota, and the Greater Yellowstone Area of Montana, Wyoming, and Idaho (Fig. 1). Because this region encompasses a wide range of climatological, topographic, and ecological variability, five subregions were delineated: West, Central, East, Greater Yellowstone Area (GYA), and Grassland (Fig. 1).

The process of conducting the NRAP CCVA (Fig. 2) included a combination of regional leadership and local science-management partnerships. This process has been successfully implemented in several previous CCVAs (Halofsky et al., 2011; Littell et al., 2012; Raymond et al., 2013, 2014), without the inclusion of subregions. A regional level leadership team organized the assessment and compiled a first draft. The assessment covered eight resource categories (water resources, fisheries, wildlife, forested vegetation, non-forested vegetation, ecological disturbance, recreation, and ecosystem services), plus a section describing projected future climate conditions. Regional-level scientists and managers selected specific resources to be covered and compiled a draft vulnerability assessment based on literature review. Workshops were held in October–November 2014 with scientists and managers in each of the five subregions to 1) capture subregional information and variability in vulnerability to climate change not addressed in the draft vulnerability assessment, and 2) develop adaptation strategies (general) and tactics (on-the-ground actions) for responding to projected effects of climate change. The regional leadership team reviewed and synthesized the information gathered from the workshops, then provided subregional participants the opportunity to review the assessment before final publication.

2.2. Framework for capturing subregional variability

We based our framework on the conceptual model of vulnerability to climate change described by the Intergovernmental Panel on Climate Change (IPCC, 2007) and recommended for application in natural resource CCVAs (Glick et al., 2011). In this model, the degree of change (exposure) and response to those changes (sensitivity) define potential impact. Impact together with the ability to alleviate or accommodate those impacts (adaptive capacity) defines vulnerability. We sought to capture subregional variability in vulnerability based on the expert opinions of subregional-level managers and scientists attending the workshops. The framework consisted of questions (Appendix A) to capture: 1) species, resources, or other information missing from the assessment (Questions 1 & 2); 2) subregional variability in sensitivity (Questions 3 & 5), exposure (Question 4), and adaptive capacity (Question 5), and; 3) additional information needed to either assess vulnerability or develop adaptation options (Question 6). In the results and discussion below, we focus on results from the wildlife resources groups.

3. Results and discussion

Across the five subregional workshops, there were four to nine participants in the wildlife resource group, excluding the discussion leader and note taker. The wildlife chapter lead author was the discussion leader at four of the five workshops, and the note taker was consistent at three of the five. In total, participants discussed 19 wildlife species (Table 1).