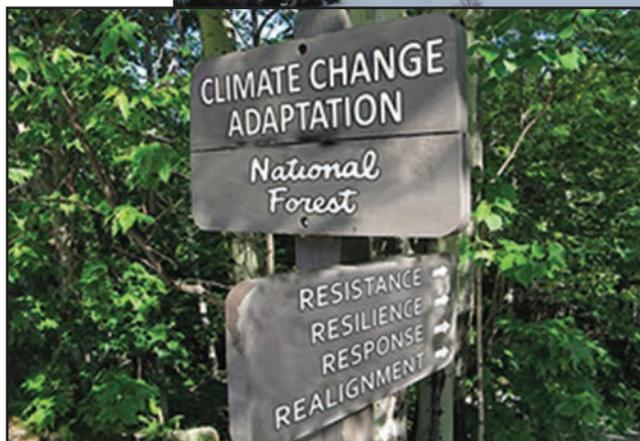
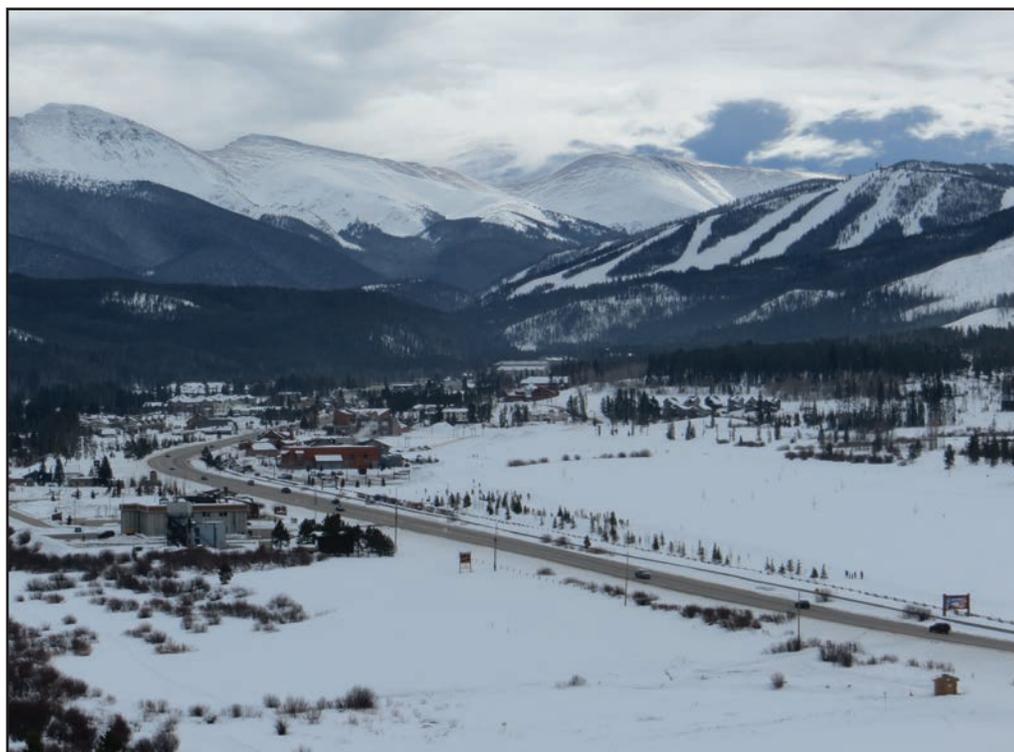


# Key Concepts and Methods in Social Vulnerability and Adaptive Capacity

Daniel J. Murphy  
Carina Wyborn  
Laurie Yung  
Daniel R. Williams



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## Abstract

National forests have been asked to assess how climate change will impact nearby human communities. To assist their thinking on this topic, we examine the concepts of social vulnerability and adaptive capacity with an emphasis on a range of theoretical and methodological approaches. This analysis is designed to help researchers and decision-makers select appropriate research approaches suited to particular planning and management needs. We first explore key conceptual frameworks and theoretical divisions, including different definitions of vulnerability and adaptive capacity. We then focus on the different methods that have been used to assess vulnerability and adaptive capacity and their respective pros and cons. Finally, we present and discuss three case examples and their respective research approaches.

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**Keywords:** climate change, adaptation, vulnerability, adaptive capacity.

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## Authors

**Daniel J. Murphy** is an Assistant Professor of Anthropology at University of Cincinnati.

**Carina Wyborn** is a Postdoctoral Research Fellow in the Department of Society and Conservation at the University of Montana.

**Laurie Yung** is an Associate Professor of Natural Resource Social Science in the Department of Society and Conservation at the University of Montana.

**Daniel R. Williams** is a Research Social Scientist at the USDA Forest Service, Rocky Mountain Research Station.

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## Introduction

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Communities<sup>1</sup> in North America face myriad ecological and socioeconomic changes due to climate change. These communities are already coping with and adapting to changes such as prolonged drought, insect and disease outbreaks, changing fire regimes, and extreme weather events. Further, climate change impacts are expected to worsen in coming decades. Human communities in close proximity to national forests, parks, or other public lands enjoy ecosystem services, natural resources, and recreation opportunities from these lands. For these communities, the local impacts of climate change have a range of negative consequences, such as affecting the ability to water crops, exacerbating fire risk and smoke levels in the wildland-urban interface (WUI), undermining the viability of local timber mills, and limiting winter tourism operations (Figure 1). Additionally, not only are these communities vulnerable to climate change impacts, but vulnerable groups within these communities might also bear a disproportionate burden from climate change.

National forests have complex and important relationships with nearby communities. For example, many communities depend on local national forests for timber supply, tourism ventures, hunting opportunities, recreation and leisure, aesthetic enjoyment, and water resources. In addition, community members have meaningful cultural, social, personal, and spiritual relationships with national forest lands. Climate change impacts on national forest lands will undoubtedly affect these relationships. Consequently, adjacent communities will be invested in, and impacted by, the adaptation actions national forests take in response to the local effects of climate change.

For that reason, Forest Service leadership has identified the need for vulnerability assessments of human communities near and/or dependent upon national forests. The Forest Service Climate Change Performance Scorecard includes an important item on community vulnerability (what we call “social vulnerability” throughout this report).



**Figure 1**—The Town of Winter Park, Colorado, is highly dependent upon winter snowpack to support its economy. Photograph by Daniel R. Williams.

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<sup>1</sup> We define communities here as human communities who are affected by management of national forests and other public lands. These are typically rural communities near or adjacent to public lands, communities with a history of natural resource-oriented economic activity, ranging from timber and grazing to outfitting and restoration. These communities are situated in a range of ecosystems, including forests, grasslands, deserts, and coastal systems. The WUI is often an important component of these communities. In some cases, urban communities are also affected by public lands management.

As a result, national forests need effective methods and tools for completing social vulnerability assessments. Alongside improved social vulnerability assessments, there is also a need for an improved understanding of adaptive capacity (and its relationship with vulnerability) and how communities might increase their adaptive capacity in the face of climate change. Pairing assessment of vulnerability with attention to improved adaptive capacity provides both a realistic picture of threats as well as possible paths toward community action and empowerment. Assessments of social vulnerability, especially when integrated with assessments of biophysical vulnerability, can help national forests understand how the local ecological effects of climate change are impacting nearby communities and their relationships with forest resources. These assessments can also assist national forests in formulating management actions that limit these impacts, wherever possible.

Recent publications have reviewed social vulnerability (e.g., see Lynn and others 2011) and some of the approaches to measuring it (e.g. see Fischer and others 2013). This report builds on and deepens those efforts through a theoretical and methodological analysis designed to guide researchers and decision-makers in selecting appropriate approaches suited to particular planning and management needs at different scales of land management. The following review examines some of the key concepts and methods in vulnerability and adaptive capacity. Drawing from a growing research literature, the Framing, Understanding, and Approaching Social Vulnerability and Adaptive Capacity section of this report explores key conceptual frameworks and theoretical divisions in this field. In this section, we discuss the different definitions of vulnerability and adaptive capacity. The Assessments and Methodologies section of the report focuses on the different methods that have been used to assess vulnerability and adaptive capacity and their respective pros and cons. This publication is intended to canvas the disciplinary diversity present in the field and to highlight why researchers, policy-makers, and practitioners should understand and be able to articulate these differences. Our goal is to demonstrate how theoretical and conceptual frameworks impact choices about methods and how methods respond to particular kinds of data needs. Ultimately, we hope to encourage both scientists and practitioners to be more explicit in the choices they make about what research to do and use through articulating the diverse frameworks used to think about or conduct social vulnerability assessments or research on adaptive capacity.

## **Framing, Understanding, and Approaching Social Vulnerability and Adaptive Capacity** \_\_\_\_\_

Social vulnerability has a long history in a number of fields. Research into the impacts of hazards has examined the vulnerability of different groups in relation to events such as earthquakes and floods for many decades. In contemporary climate change research, definitions of vulnerability and adaptive capacity are more variable. Climate change introduces a level of uncertainty and spatial pervasiveness that challenges the traditional view of hazards as containing distinct phases: (1) pre-event, (2) event, and (3) post-event or distinct impact zones such as a “landfall site” or “epicenter.” In contrast, climate change impacts are long-term, multi-scale, and widely distributed, though potentially uneven across time and space.

With this in mind, the Intergovernmental Panel on Climate Change (IPCC) has defined vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity” (McCarthy and others 2001:21). In this

influential definition, exposure refers to the proximity of units or systems to disturbances resulting from climatic variation and sensitivity refers to the susceptibility of potential loss from these impacts. Adaptive capacity is defined as an element of vulnerability that includes “the *characteristics* of communities, countries, and regions that influence their propensity or ability to adapt” (McCarthy and others 2001:18, emphasis added). These definitions are often represented in the formula:

$$\text{Exposure} + \text{Sensitivity} + \text{Adaptive Capacity} = \text{Vulnerability}$$

The definition and representation of vulnerability in this formula has significantly influenced the design of vulnerability assessments as it forces us to consider how different factors contribute to vulnerability. However, as recognized in the most recent IPCC report (2014), conceptualizing vulnerability in this simple linear formula neglects the broader social, political, and economic forces shaping how a community is affected by natural disturbance. Further, the three terms in the formula often lack clear definitions, and their definitions differ across fields and disciplines (Hinkel 2011).

Different definitions and conceptual frameworks shape how vulnerability and adaptive capacity are understood and examined. For example, some describe vulnerability as a state of powerlessness (Hewitt 1997) or the presence of unsafe conditions (Wisner and others 2004), while others see vulnerability simply as an exposure to some external natural phenomenon. Viewing vulnerability as a function of exposure to natural phenomenon directs the research lens to examine the extent, magnitude, and probability of different climate-based hazards. In contrast, viewing vulnerability as a state of powerlessness directs attention to the broader socio-political structures and processes that shape the distribution of impact across society. For example, vulnerability to drought could be viewed as the condition of a community being located in an area where there is a regional absence of precipitation or as a function of access to water resources. The former frames drought as a purely biophysical process while the later focuses on the socio-political processes that determine water rights and distribution. Different ways of conceptualizing vulnerability also raise different ethical questions (see Box 1).

A key element of vulnerability is adaptive capacity—a much more difficult and complex concept to define. Adaptive capacity focuses on the capacity of individuals, social groups, and organizations to pursue adaptation. Adaptive capacity is related to the availability and distribution of knowledge, resources and technology, management and decision-making processes, regulations and policies, levels of social and human capital, and perceptions of risk and individual or collective ability to influence change (Yohe and Tol 2002; O’Brien and Hochachka 2010). The adaptive capacity of a community is a combination of characteristics that are internal to an individual, community, or organization and external factors that are beyond their control that either enable or constrain their ability to respond to change. For example, a community may have the resources and shared motivation to store more water in the landscape in stock ponds or reservoirs in order to provide a buffer against drought. However, without water rights, they may be unable to build on their capacity to undertake adaptation.

In thinking about adaptation and adaptive capacity, the principal questions concern *what* is adapting, to *what* and *why*, and *where* does the capacity to adapt come from (Smit and others 2000). Adaptive actions respond to different needs at different scales (e.g., individual, community, region, and nation), and such actions are shaped by capacities at those scales. Climate change is one of many drivers influencing the decisions of communities and individuals, and it can be difficult to separate out a singular driver of change from the complex and multi-scalar forces shaping landscapes and communities.

### **Box 1: Implications of Scale for Vulnerability Assessments**

Scale is an issue that receives significant attention in the literature focused on vulnerability and adaptive capacity. Many researchers recognize that the processes driving both vulnerability in the broad sense and, specifically, the component of adaptive capacity are often removed—spatially, temporally, or politically—from an affected area or population (Smit and Wandel 2006; Adger and others 2009). In a globalized world, virtually all social, ecological, economic, or cultural systems have external drivers at different scales and levels. Thus, it is critical to understand the multi-scalar dimensions driving vulnerability and adaptive capacity.

In the search for determinants and indicators of adaptive capacity, a growing critique has emerged arguing that indicators will differ depending on the scale of the adaptive unit being analyzed (Wilbanks and Kates 1999; Adger and Vincent 2005; Vincent 2007). For instance, the characteristics of adaptive capacity within households will be significantly different than those for communities or for countries (Adger and Vincent 2005; Vincent 2007) and for individuals (Grothman and Patt 2005). Yet, these forms of social organization are also nested, as nation-states consist of and govern communities and households, and communities are embedded in nation-states (Adger and others 2009).

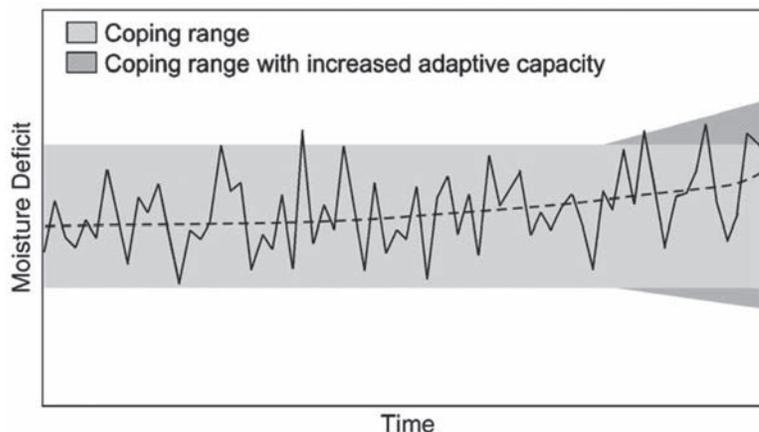
Consequently, the scale issue is more critical than simply selecting some kind of exposure; rather, the issues concern: (1) how exposure units are implicated at various scales, and (2) how the scalar nature of the unit is produced. Both vulnerability and adaptive capacity depend on a variety of social, political, economic, technological, and institutional factors whose interactions differ depending on the scale of analysis (Vincent 2007). At a national scale, adaptive capacity is not only a function of the availability of resources but also the ability to direct resources to areas of greatest need. At a household level, more common drivers are the knowledge base of an individual, the availability of alternative livelihoods, or access to resources. As these factors interact across scales, vulnerability assessments need to account for cross-spatial and cross-scalar processes and outcomes (Eakin and Luers 2006).

In practice, this entails understanding the factors driving vulnerability that may not be obvious at the site of concern. For example, the water flowing through a particular county, community, or watershed may seem sufficient for the population and land use in the area. However, if non-local entities (landowners, urban centers, etc.) own water rights to local water, the water available to local communities may be insufficient. Only through understanding the broader regulatory context within which water is governed can a complete picture of useable water be found. Likewise, scales of adaptive capacity are interdependent: a household's capacity to cope is, to a certain extent, mediated by the adaptive capacity of the community and the regional availability of resources (Yohe and Tol 2002; Smit and Wandel 2006). Contextual approaches to vulnerability are more likely to pay attention to scale, as these approaches are concerned with identifying how broader socio-political and economic forces shape vulnerability.

Understanding forces and processes at non-local scales requires a methodological approach that recognizes and examines factors that occur at multiple scales (Wilbanks and Kates 1999; Gibson and others 2000). Further, it is important to recognize that macro-scale processes are fundamentally different from those operating at a smaller scale. An adaptation program designed for a small and relatively uniform community is unlikely to be readily transferred to a regional center with a diverse population and a broader income base.

This also brings in the question of whether adaptation is a *process of structural change* in response to external stressors or a *state of adaptedness* in which the structural characteristics of a system are effective in dealing with its environment (Young and Lipton 2006, emphasis added). In some cases, climate change impacts may be so significant that existing industries, such as flyfishing tourism, or infrastructures, such as fire suppression resources, are no longer viable. Such circumstances may require structural changes involving changes to land use or reconfiguring the ways that decisions are made. In contrast, a state of adaptedness exists when decision-making processes or industries are configured to enable responses to changes in climate. Smit and others (2000) also pointed out that adaptations can be anticipatory (anticipating future change) or reactive (reacting to current or immediate threats), autonomous (pursued by individuals) or planned (pursued by organizations, communities, or governments). Some researchers explore adaptive capacity in reference only to specific events, risks, or thresholds, while others are more concerned with what might be called a generic capacity to adapt (a broad capacity to adapt to many different kinds of changes) (Lemos and others 2013).

A significant portion of the literature on adaptive capacity is concerned not so much with adaptation or capacity in any theoretical sense, but with adaptive *actions*. Thus, vulnerability is often seen as the lack of such action or capacity to engage in adaptive actions. To be adaptive is to alter the direction of management in response to social, political, or ecological changes. For example, changes in spring green up may impact the timing of forage availability on the range. An adaptive action in response to this change might be to alter the start date for a grazing allotment. Nelson and others (2007) and Smit and Wandel (2006) explained the difference between coping and adaptation. Coping action tends to be used to describe shorter-term adjustments made to simply survive a disturbance, whereas adaptive actions describe longer-term, more sustainable adjustments. Coping actions are not adaptive in the sense that they do not support transformative change, that is, complete reorganization or transformation of current management. Figure 2 graphically represents the coping range, demonstrating the range of variability under which coping strategies may provide a buffer against change. However, coping ranges and adaptive capacity are not static; steps can be taken to increase the coping range, or conversely, decisions can erode a coping range (Smit and Wandel 2006). For example, a rancher might cope with drought by reducing herd size. However, switching to a drought-tolerant cattle breed might improve the ability to deal with future droughts, thereby increasing the coping range.



**Figure 2**—Smit and Wandel (2006) depicted the way in which coping range expands as adaptive capacity grows.

Coping often focuses on the actions individuals or communities have taken in the past in response to a specific change or hazard. However, the usefulness of past responses in future adaptations is uncertain, as climate change may lead to fundamentally new conditions compared with those in the past. When a system is undergoing large-scale changes that exceed functional thresholds, coping is no longer effective; rather, the system and system elements must adapt to novel conditions. For example, a community might suppress a wildfire to cope with threats to life and property. But, in the longer-term, suppression increases fuel levels, which may result in more intense, larger fires in the future and more difficulty suppressing such fires. An adaptive action could involve enabling fires to burn in areas where there is no threat to life and property, while a transformative action could be to reconsider the patterns of development in the WUI. Similarly, a local mill facing a timber shortage may truck in raw logs from far away forests to remain productive. But, after a number of years, the added expense may decrease their competitiveness and result in closure. This type of action is known as maladaptation, whereby the adaptive response simply delays the onset of a larger problem or creates feedbacks that further exacerbate the problem. While not always possible, maladaptive responses can be avoided by thinking through and assessing the causal drivers of change and assessing these factors during adaptation planning. In the prior example, an adaptive or even transformative response might be to retool the mill to focus on the small diameter timber being harvested to reduce fuel levels.

## **Conceptual Frameworks**

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Underlying these broad definitions are different conceptual frameworks that focus attention on different elements of vulnerability and adaptive capacity. A conceptual framework is an analytical tool used to organize ideas and communicate the theoretical logic behind a way of viewing the world. It is important to understand the conceptual frameworks behind interpretations of vulnerability and adaptive capacity because they focus attention on different elements of a problem, and lead to different research questions, new knowledge, and concomitant management or policy responses. We identified four key conceptual frameworks within the literature: actor-oriented, systems-oriented, outcome-oriented, and context-oriented. Our intention in laying out these different frameworks is to illustrate the diversity of conceptual and methodological approaches adopted in studies of vulnerability and adaptive capacity.

To illuminate some of the differences among these approaches, we will describe the key concepts and frameworks presented in Table 1. These conceptual frameworks lend themselves to different assessment approaches and methodologies, which will be discussed in the Assessments and Methodologies section. Surveying the array of approaches and methodologies is a critical and necessary step prior to undertaking an assessment of vulnerability and/or adaptive capacity. Understanding the goals and focus of an assessment, the nature of the available data, and the strengths and weakness of different approaches will ultimately lead to a more useable project tailored to specific needs and context.

### **Actor-Oriented Versus Systems-Oriented Approaches**

To begin, we explore a distinction highlighted by Nelson and others (2007) between actor-oriented and systems-oriented research. We then discuss the difference between outcome-focused and contextual-based conceptual frameworks before moving on to survey a range of different assessments and methodologies utilized to assess vulnerability and adaptive capacity.

**Table 1**—Key conceptual frameworks in social vulnerability and adaptive capacity.

Framework	Focus	Goal	Key concepts	Pros	Cons
<b>Actor-oriented</b>	Exposure units and courses of action.	Outline constraints and opportunities for specific actors, their decisions, and their actions	Rational choice approach focuses on decision-making. Relational approach focuses on context (see Context-oriented).	Combines context-orientation and outcome-orientation. Applicable at multiple spatial scales and with various exposure units.	Overly specific. Can miss structural dynamics.
<b>Systems-oriented</b>	Exposure and resilience of relationships that make up systems.	Outline functional relationships and dynamic response to change.	Coupled human-natural systems involving feedbacks and linkages. Resilience: adapting while retaining function. Resistance: averting change. Thresholds: transformative change.	Focuses on relationships. Concerned with transformative change.	Too abstract. Terms are ambiguously defined.
<b>Outcome-oriented</b>	Impacts of objective threats on discrete exposure units.	Demonstrate causal relationship between hazard and loss.	Hazards-based approach, focuses on exposure units and impacts. Vulnerability is a function of impact and exposure.	Targeted and narrow with discrete variables. Comparative. Easily applied. Uses existing data.	Misses important dynamics. Can be reductionist, decontextualized, and aprocessual.
<b>Context-oriented</b>	The spatial and temporal scales that produce constraints and opportunities.	Demonstrate the complexity of vulnerability and adaptation.	Political economy (institutions, policies, etc.). Moral economy (values, perceptions, etc.).	More accurately reflects reality. Broader vision of drivers of change.	Lack of agency. Lack of scaling up. Overly specific.

## Actor-Oriented Approaches to Social Vulnerability

Actor-oriented perspectives focus on discernible exposure and/or adaptive units such as countries, communities, households, and individuals or on specific attributes of units such as wellbeing, livelihood, or health. These approaches assume that actors (individuals or groups/collectives) have agency and can influence and shape the world around them. There are two bodies of actor-oriented research: (1) rational choice approaches, and (2) relational approaches. These approaches seek to understand how vulnerability is produced through a broader set of interactions in which actors and exposed units are situated.

The rational choice approach focuses on constraints and opportunities only in the way they impact an actor’s decision-making processes. For example, Yohe and Tol (2002) included the following:

1. the range of available technological options,
2. the availability of resources and distribution,
3. the structure of institutions,
4. stocks of human and social capital,
5. access to risk-spreading mechanisms,
6. ability of decision-makers to deal with risk and information,
7. the public’s perception, and
8. the significance of exposure.

Actors in this approach are treated as largely autonomous from society and broad social structures and, therefore, are seen as independent navigators of a landscape of options and barriers. Pelling (2010) argued that “too often th[is] literature reduces the individual to a rational economic actor” and misses the broader social forces and conditions that turn people into exposure units.

In relational approaches, vulnerabilities and adaptations are a result of relationships: (1) between exposed units (or the relationships that sustain these units) and stressors, and (2) between those units and relationships with social forces at local and non-local scales. Relational approaches see the world as a series of interactions among actors, institutions, and contexts, whereby the interactions between entities change their identity. Relational perspectives focus on how vulnerability, adaptive capacity, and adaptation co-evolve through the interactions among social and political institutions, communities, and economies. Accordingly, understanding the relationships and interactions among individuals, communities, institutions, and policies, as well as their relationships with climate-driven stressors such as drought or forest insects is key to understanding social vulnerability (Figure 3).

A relational approach also requires a focus on the informal and formal networks, institutions, and organizations that constitute social relationships through ethics and morals, social norms, formal policies, and cultural forces. Relational analyses examine the integration of actors, and the structure of relationships in both horizontal (i.e., local) and vertical (i.e., non-local) networks (Ingold and others 2010). In relational approaches to vulnerability and adaptation, interactions or relationships across scales are particularly important (Rodima-Taylor 2012). For example, in order to effectively evaluate a community’s vulnerability, one must consider the relationship between the community and public agencies such as the Forest Service and how they affect one another. The adaptive capacity of communities with antagonistic relations with public agencies will be very different from those with more agreeable relations. A relational approach would inquire into how these different relationships shape, enable, or constrain vulnerability and adaptive capacity.



**Figure 3**—Beaver slide, which is used for stacking hay, dot the landscape in the Big Hole, Montana. The slides are indicators of both the viability of ranching as a livelihood, as well as ranching’s place in the Big Hole community identity. Photo by USDA-NCRS.

## Systems-Oriented Approaches to Social Vulnerability

Not all researchers are concerned specifically with exposure units. Instead, some research focuses on the vulnerability and adaptive capacity of systems. Much of this work draws on the social-ecological systems literature that attempts to conceptually couple human and natural systems (Gunderson and Holling 2002; Berkes 2007). Central to this framework are the notions of feedbacks, linkages, and resilience. Feedbacks refer to processes that reinforce or modify the behavior of a system—for example, the way forests respond to fire, or how a community changes behavior in response to a fire event. Systems approaches use the concept of linkages to refer to the connections or points of interactions between different elements of a system, such as the way management and forest communities are partially integrated, or the relationship between fish stocks and quotas for fishing in a marine system. Resilience refers to the ability of a system to undergo change while maintaining the capacity to retain, re-organize, or regain the same structure and function prior to disturbance. These concepts illustrate the dynamic and relational dimensions of adaptive capacity and vulnerability as they direct attention to the interactions among aspects of a system and how they change over time. The focus on linkages and feedbacks within social-ecological systems highlights how vulnerability can emerge from social or ecological processes and the interconnections between these two domains (Nelson and others 2007).

Conceptualizing the vulnerability of systems rather than exposure units changes how we think about exposure, sensitivity, and other aspects of vulnerability. According to a systems approach, exposure units can only be conceived in their relations and not as independent, discrete entities (note the overlap with the relational approach previously discussed). Systems perspectives point to the importance of attending to thresholds, which represent the boundaries around which a system remains in a particular state (Nelson and others 2007). For instance, when a relationship between units is exposed to a hazardous threat, there is, at some level, a threshold point beyond which that relationship is no longer functionally possible within novel conditions. For example, if a ski resort community no longer gets enough snow to maintain operations, a local economy built around winter recreation may not be possible. Thinking about vulnerability and adaptive capacity in this way is critical because climate change poses such transformative threats to various social-ecological systems around the globe.

The focus of a systems-oriented approach continues to center on exposed units with “units” contextualized within broader systems (or even with systems as exposure units). Problematically, much of this work also continues to conceptually divorce social systems from natural ones. For instance, climate change is often positioned as an external threat to the system rather than as a system-generated disturbance. This is an important point because what is included or excluded from the definition of the system can shape how we think of vulnerability and adaptive capacity. Moreover, a systems approach so far has also encountered significant difficulties in dealing with issues of social or political power and may overlook the fact that different individuals, communities, and organizations have unequal abilities to act and adapt to change (Davidson 2010; Thornton and Manasfi 2010).

Researchers have highlighted two possible adaptive responses: resistance or resilience. Resistance focuses on efforts to resist the local effects of climate change or delay the impacts (e.g., by maintaining or investing in existing system relationships, including current practices, livelihoods, and institutions). Resilience focuses on adapting in ways that preserve functionality through new system relationships that can better weather change (e.g., local livelihoods are possible but might shift to new sectors; water is available for irrigation but practices change; and timber is harvested but better adapted species are replanted). In the context of forest communities, resistance might entail replanting species that have historically been present due to their value for timber production, even

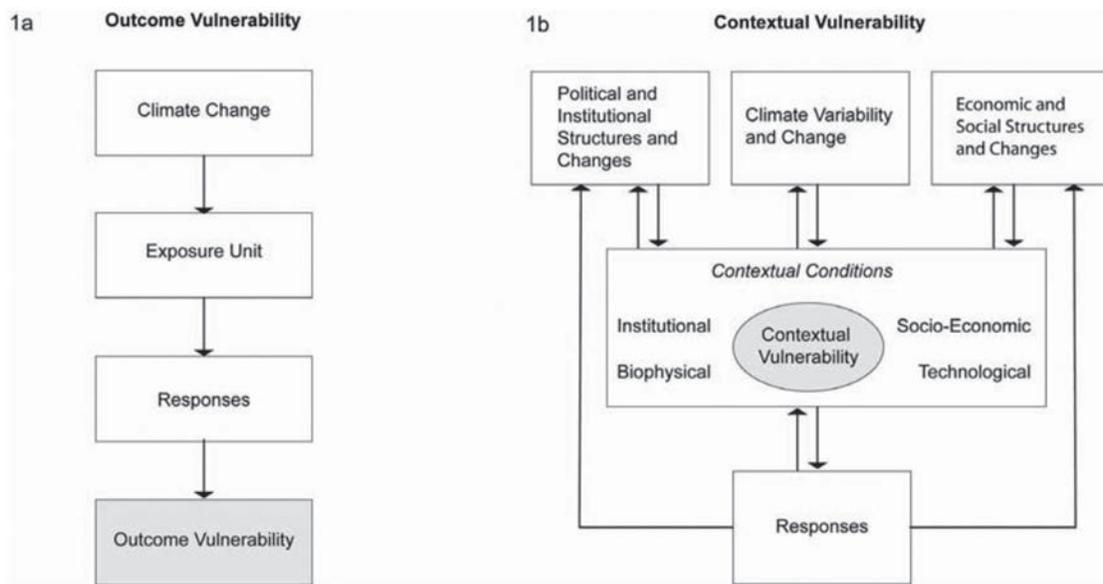
though such species do not thrive under predicted future conditions such as drought. In contrast, if such a community accepted system transformation, they might pursue tree species with commercial value that are predicted to do well under future conditions. Another example of an adaptation that increases resilience by embracing transformation is to establish water conservation measures to meet the needs of water users under future precipitation scenarios.

## Outcome-Oriented Versus Contextual Frameworks

As recognized in the most recent IPCC report (2014), another key difference in how vulnerability is conceptualized revolves around the focus on either outcomes or process. O'Brien and others (2007) argued that there is a distinction between an outcome approach, which is focused solely on actual losses, and a contextual approach, which is focused on the conditions, processes, and contextual dynamics that enable loss. Figure 4 depicts the differences between outcome and context-oriented approaches to vulnerability. In particular, outcome-oriented approaches are more linear and narrowly frame vulnerability as a function of climate impacts on exposed units, whereas contextual approaches focus on a multitude of social, political, economic, institutional, and biophysical conditions that, through their interactions, produce vulnerability.

### Outcome Approaches to Social Vulnerability

Outcome approaches tend to follow along two lines: starting point and end point research (O'Brien and others 2007). Starting point assessments begin by identifying sensitivity (the susceptibility to potential impacts) to exposure (the magnitude of the impact) in relation to a community's capacity to respond to stress. Accordingly, vulnerability is envisioned as a condition inherent in certain populations. While this is similar to the actor- and system-oriented approaches, in an outcome-oriented approach, the focus is on the populations themselves rather than the broader system in which they are situated. The assumption is that certain characteristics, such as poverty, lack



**Figure 4**—Distinctions between outcome vulnerability and contextual vulnerability (from O'Brien and others 2007).

of education, or minority status, make certain groups inherently more vulnerable to the impacts of climate change (see Lynn and others 2011 for a detailed discussion of how demographic characteristics influence social vulnerability). The strength of this research is that it enables a rapid assessment of sensitivity, or the differential or uneven impacts of climate change on human communities. That said, sensitivity is seen largely as a fixed characteristic or set of attributes rather than as dynamic and emerging from a complex context that produces both vulnerability and adaptive capacity. In contrast, end point assessments focus on exposure. Future vulnerability is assessed in response to a specific event. Analysis begins with projections of future emissions trends, which are then used to understand biophysical impacts and the susceptibility of different regions, groups, or sectors to specific losses generated by those impacts. Both starting point and end point approaches see vulnerability as an outcome of a climate stressor on a vulnerable population rather than the broader contextual approaches that consider vulnerability to be a function of a broader array of processes.

Accordingly, vulnerability is seen largely as exposure to an objective threat, such as sea level rise, increased fire frequency, or reduced winter snowpack. Adaptive capacity, the ability to adapt to such threats, is viewed as the inverse of vulnerability. These studies quantify loss potential, sectoral impacts, and appropriateness of technological adaptations (O'Brien and others 2007). For example, research might examine the impact of temperature change on forage and livestock production in rangelands. A number of assumptions underlie this perspective. First, exposure/adaptive units are easily identifiable and experience discrete impacts. Secondly, since much of this research utilizes a dose-response methodology (see the Dose-Response section), the exposure/adaptive unit is taken as an independent variable and is divorced from contextual dynamics. For example, the response of individual households to forest fire is examined independent of fire ecology, local fuel reduction efforts, national fire policy, and agency capacity to manage fire. In adaptive capacity research, similar frameworks compare exposure/adaptive units in order to understand why losses did not occur. Outcome research, both starting and end point approaches, have been criticized for not considering politics, context, and process because research in this arena sometimes avoids the vast complexities that produce and sustain vulnerabilities, adaptive capacity, and adaptations.

## **Contextual Approaches to Social Vulnerability**

Contextual approaches envision vulnerability and adaptive capacity as highly contextualized within social, political, economic, and ecological contexts at multiple scales from local to global. In particular, a contextual approach examines institutional constraints, social and economic barriers, and underlying historical processes and the differential capacities and sensitivities these induce. Context-oriented research is more complex in its considerations than outcome-oriented approaches, examining the various ways that vulnerability and adaptation are constrained or enabled (largely reflecting the list by Yohe and Tol 2002).

As such, contextual approaches typically consider governance issues (Adger and others 2009). At the community level, adaptation measures must take into account the will of local citizens, nongovernmental organizations, and local governing bodies. Wall and Marzall (2006) and Zarhan and others (2008) highlighted the ways in which governance influences the relevance, credibility, and legitimacy of different actions to local communities that are seen as critical to formulating potential course(s) of action. A number of works have also highlighted the importance of top-down governance issues in shaping adaptive actions at the local scale (Eakin and Lemos 2006; Pahl-Wostl 2009). In the case of national forests, both top-down federal policies and initiatives and local community- and Forest-level governance will need to be considered when thinking about social vulnerability.

Contextual approaches also consider the social, psychological, and cultural limits to adaptation (Crate and Nuttall 2009; Hulme 2009; Norgaard 2011). For example, climate change perceptions and beliefs influence the possibility for action. These kinds of perceptions are also implicated in how individuals, communities, and societies view risk and thus vulnerability (Shackley and Deanwood 2002; Tucker and others 2010). For example, people's beliefs about climate change may influence whether or not they see projected changes to in-stream flow and native fisheries as problematic, and how they describe the vulnerability of local fishing outfitters to climate change. Interest in and motivation to adapt is influenced by values, interests, and political ideologies (Adger 2006; Roberts and Parks 2006). For example, when local changes are viewed as part of natural variability (a common view among climate skeptics), the need for adaptive actions may not be considered important as this perspective assumes that changing conditions, such as water shortages, are only temporary. In contrast, when local changes are viewed as part of a longer trend (i.e., climate change), adaptive actions may be viewed as a priority.

Contextual approaches also examine the way society and its members learn and the connections between that learning process and subsequent action (Pelling and others 2008; Tschakert and Dietrich 2010; Krasny and others 2011). Experimentation, imitation, communication, and reflection are seen as critical elements in somewhat nebulous networks of learning and knowledge production that fill in the spaces between formal institutions (Berkhout and others 2006; Krasny and others 2011). Thus, the informal networks within forest communities and the capacity of such networks to learn from and respond to local changes, such as beetle outbreaks, floods, or fire, are an important component of adaptive capacity.

Lastly, contextual approaches explore the ways that local adaptive capacity and vulnerability are connected to global processes. As Adger and others (2009:150) pointed out, the "vulnerability of specific individuals and communities is not geographically bounded but rather is connected at different scales, so that the drivers of their exposure and sensitivity are inseparable from large-scale processes of sociocultural change and market integration." In this way, issues of scale complicate vulnerability assessments as the processes driving change are often spatially or temporally removed from the site of concern (see Box 2). Leichenko and O'Brien (2002, 2008) and O'Brien and Leichenko (2003), for instance, demonstrate that multiple stressors, originating from complex and trans-local networks, can interact to create "double exposures," deepening vulnerability. In their work, they demonstrate how climate change stressors (i.e., increasing drought with a shorter but more dramatic monsoon season) and global economic shifts (i.e., decreasing crop prices) combined to impact the vulnerability of a rural Indian farming community. In many ways, these observations are equally true regarding adaptive capacity. A beetle outbreak, combined with the closure of a mill due to increases in Canadian lumber imports and the price of wood products, could affect a forest community's ability to respond to change.

## Summary

We outlined some of the different ways that vulnerability is conceptualized, from systems- to actor-oriented, and outcome- to context-oriented perspectives. Critical differences concern the factors that may influence vulnerability and how these factors are understood and examined. These differences can be thought of as falling around different conceptual scales: the difference between systems and actor approaches is the focus on the individual agent (actor-oriented) versus the broader context of vulnerability (systems-oriented), whereas outcome and contextual approaches are distinguished

### **Box 2: Ethics and Vulnerability Assessments**

Assessments of vulnerability raise important ethical questions concerning the conduct and implications of research. Understanding how communities are differentially affected by climate change is a principal driver of vulnerability assessments. These assessments raise questions about ethics and equity, as vulnerability is a product of access to resources, risk exposure, and the socio-political context that has created these conditions now and into the future (Eakins and Luers 2006; Ribot 2011). Once complete, vulnerability assessments stimulate broader questions for policy and practice. Why is a particular group vulnerable or at risk, and what are the possible steps that can be taken to address the condition of vulnerability? Is the research complete once the vulnerable populations are identified, or is there a responsibility to act on this knowledge? In some agency contexts, the policies or politics may prevent researchers from directly acting on vulnerability assessments. This does not, however, negate consideration of the ethical implications of the research.

The very act of labeling a social group, community, or region as vulnerable should be viewed with caution. Such a label has the potential to construe these groups or individuals as passive victims, ignoring their potential agency (the ability of individuals or groups to make change). Agency is apparent in contextual research, which focuses on the broader socio-political forces shaping vulnerability. Seeing vulnerability only as a state of “powerlessness” (Hewitt 1997) can result from outcomes-oriented indicator research because there is little attention devoted to why a particular group is vulnerable and who is responsible for creating or addressing drivers of vulnerability. Acknowledging the creative and powerful actions of the vulnerable is particularly important if we want forest communities to be active participants in developing adaptation actions in the face of climate change. Further, when vulnerability assessments are used as a platform for allocating resources or designing policy, wrongly labeling a group as vulnerable not only denies their agency in addressing solutions, but finite resources could be allocated to areas with less need at the cost of those with greater needs for assistance.

Importantly, what constitutes damage, negative effects, or adaptation varies across contexts and cultures. Vulnerability research is unavoidably grounded in human values attached to particular places, populations, and systems (Farely and Costanza 2002; Eakin and Luers 2006; O’Brien and others 2007). Support for adaptation and mitigation to address vulnerability contain (often hidden) value judgments about the relative importance of certain communities or social groups. Even rigorous scientific research using metrics and indicators involves simplification and aggregation of complex processes to enable analysis. Reconfiguring these metrics can produce vastly different results with significant implications for understanding who is vulnerable and what can or should be done (Nelson and others 2010; see Case Example Two).

by the scope of factors considered to shape or produce vulnerability. Outcome-based approaches tend to adopt a more narrow focus, largely mirroring the IPCC definition of vulnerability, while contextual approaches adopt a more holistic picture of how the socio-political and historical context shapes vulnerability. This conceptual complexity makes it difficult to sort out the influence of these different perspectives on how we understand and assess vulnerability and adaptive capacity. Still, the important insight to take away from this discussion is that different ways of thinking about and conceptualizing vulnerability highlight and prioritize different aspects of vulnerability and adaptive capacity. Emerging from the complexity, the next step is to understand how these ideas are applied in practice.

## Assessments and Methodologies

Not surprisingly, social vulnerability is measured in a number of different ways, as different conceptual frameworks imply different data needs (Costa and Kropp 2013) (see Table 2). For example, contextual approaches are more likely to search for the broader social, political, and economic forces driving vulnerability and are more likely to adopt methods that illuminate these factors at a local scale. In contrast, outcome-oriented research is more likely to focus on indicators of vulnerability that measure and monitor the potential impacts of an event or disturbance on a population or sector of the community.

**Table 2**—Methods for research and assessment.

Research design and/or methodology	Elements	Pros	Cons
<b>Dose-Response (Outcome-oriented)</b>	Vulnerability is assessed through quantitatively measured impacts.	Targeted, simple, and cost efficient.	Only applicable to past events, highly reductionist, and utilizes only quantitative data.
<b>Indices and Indicators (Outcome-oriented)</b>	Past event data are used to create index, weighted through expert elicitation, and then used to assess relative vulnerability or adaptive capacity.	Good for targeting. High external validity (presumed). Scalable and cost effective. Data are easily accessible. Can be represented spatially on a map.	Founded on core assumptions that may be misleading. Reductionist. Serious measurement issues. Typically only uses quantitative data.
<b>Case Studies (actor- and context-oriented)</b>	Empirically trace out drivers and processes from “field.”	Highly detailed, complex, and realistic understandings. Empirically rich.	Time intensive, overly specific, complex, and costs can be high. Not always scalable.
<b>Scenario-building (Combination of outcome and context-oriented)</b>	Climate models used to assess future impacts or to plan for future adaptation. Successive “what if” scenarios are presented.	Useful in quantitative and qualitative research designs. Can be used in participatory work. Helps decision-makers and community members work through problems.	Highly specific and localized. Methods can be scaled up, but not necessarily findings.
<b>Participatory (actor- and context-oriented, could be systems- and outcome-oriented)</b>	Assessment through locally meaningful research.	Locally meaningful, cost-effective, and considers widest range of perspectives.	Overly specific, may be clouded by local perceptions, not scalable, and may experience resistance.

Eakin and Luers (2006) identified twelve components of a vulnerability assessment along with associated questions (see Table 3). These questions (and their answers) can inform decisions about the scope of the study and the research questions. Questions such as *What is the scope of the assessment?* and *Why do we care?* help focus a vulnerability assessment. Questions such as *What social and biophysical factors are driving change in the system?* and *Who loses, who gains?* can be seen as possible research questions. When the assessment is connected to adaptation policy and planning, understanding why certain communities are vulnerable helps to develop appropriate management actions and responses.

**Table 3**—Core components of vulnerability assessment (Eakin and Luers 2006).

<b>Assessment component</b>	<b>Questions</b>
<b>Definition of the system</b>	What is the scope of the assessment?
<b>Definition of the desired state(s) of the system</b>	Why do we care? What future is valued highly in this system? Whose values are important, and why?
<b>Definition of the exposure units</b>	Who or what is potentially vulnerable?
<b>Identification of attributes of concern and definition of damage</b>	What is dangerous or undesirable for the unit(s) of analysis? What is dangerous for the system of study? What is the relationship between harm and the unit of study and harm and the human environment system?
<b>Identification of proximate and underlying drivers of the system</b>	What social and biophysical factors are driving change in the system?
<b>Delineation of interactions among drivers</b>	What are the immediate threats, and how are they evolving?
<b>Delineation of interactions between drivers and unit(s) of analysis</b>	What are the greatest uncertainties about the system's change? What are the underlying causes of differential susceptibility?
<b>Evaluation of differential capacities and sensitivities</b>	Who or what has the least capacity to respond, and why? What explains differential capacities to cope and adapt? Why and how do systems change?
<b>Identification of thresholds of change</b>	How can a shift in the state of the system be observed? What indicators will signal that a threshold has been passed? How does the identified threshold relate to the desired state of the system or welfare of the unit(s) of exposure?
<b>Model relationship between stressors, attributes, and outcomes</b>	How does the system respond to stress?
<b>Characterization and evaluation of plausible outcomes of change</b>	What range of changes can be expected? What outcomes are least tolerable? Who loses, and who gains?
<b>Characterization of adaptation actions</b>	What actions can be taken now to increase future flexibility? What capacities are needed to enable desired response to change? What policies are needed to support these capacities?

Because no two communities, landscapes, or local economies are the same, vulnerability assessments are likely to be most effective when tailored to a specific context, such as climate change on a particular national forest. Hinkel (2011) identified the following motivations for assessing vulnerability:

1. Identify mitigation targets
2. Identify particularly vulnerable people, regions, or sectors
3. Raise awareness of climate change
4. Allocate adaptation funds to particular vulnerable regions, sectors, or groups of people
5. Monitor the performance of adaptation policy
6. Conduct scientific research

This diversity of motivations combined with the diversity of definitions previously discussed and the diversity of communities for which a social vulnerability assessment might be conducted mean that methods are unlikely to boil down to a single recipe (Eakins and Luers 2006). For example, a participatory approach engaging different actors in developing a community-scale vulnerability assessment is more likely to raise awareness about climate change (at that local scale) than an expert-led process to develop indicators and metrics of vulnerability. These indicators and metrics are, however, useful to identify vulnerable populations, regions, or sectors, highlighting where policy or future research should target adaptive strategies or efforts.

The following discussion outlines the primary methods used in vulnerability research and assessment. Here, we highlight the strengths and weaknesses of these approaches and have included three case studies to illustrate how these approaches have been applied in practice.

## **Dose-Response**

The primary methodology of large-scale, outcome-oriented, climate change vulnerability analyses involves some kind of dose-response model of experimentation (O'Brien and others 2007). In a dose-response approach, vulnerabilities are measured through the impact a particular hazard inflicts on a given population or economic sector. The dose is the magnitude of the hazard—the size of a flood or duration of a drought, for example. Dose-response research focuses on understanding which regions, communities, or economic sectors are exposed to a particular climate-related hazard and the extent to which they are exposed. For example, this work might explore the impact of wildfire distribution and frequency on home values. Geographic Information System (GIS) analyses can be utilized to examine the spatial impact of different “doses” or amounts of a hazard experienced. This produces spatial information indicating who is exposed to a particular hazard. Dose-response research can reveal which groups or communities are more likely to be exposed to a particular hazard, such as sea level rise, fire, or drought, but it does not measure sensitivity to those hazards and is thus an imperfect measure of social vulnerability.

## Indices and Indicators

Much of the research on climate change vulnerability has utilized some kind of indicator methodology. As previously discussed, indicators are most often associated with an outcome-oriented approach and are typically based on an assumption that vulnerability is something inherent in certain social groups (e.g., the poor). In this vein, the determinants and drivers of vulnerability and adaptation, such as income and education level, are derived from broader literature and case studies of hazard impacts and outcomes (Ligon and Schechter 2003; Brooks and others 2005; Birkmann 2006; Jones and Andrey 2007; Johnson and others 2009). Researchers rely on expert elicitation to weigh particular indicators, such as income, gender, or education, and then use the established index to rank or rate households, communities, or larger units, such as countries, according to their relative vulnerability or adaptive capacity. This research is scalable and cost-effective because it relies solely on existing data sources, such as census data. It has also been highly valued as a targeting tool. For example, an index derived from expert elicitation and existing data on hazards could enable communities to be assessed, ranked, and targeted for vulnerability reduction and adaptive capacity building. Indicator data can also be represented spatially on a map, which enables decision-makers to consider vulnerability “hot spots” as they consider different approaches to climate change adaptation.

While indicator studies are quite popular, there are a number of concerns about their utility. For instance, these studies may not necessarily measure what they intend to measure, as they can oversimplify complex relationships between variables and the associated metrics are often determined by data availability rather than the underlying validity of the available parameters. Additionally, participating experts may not have a complete understanding of the phenomena and indicators that predict vulnerability in one context may not translate to other contexts as hypothesized relationships between variables may not exist in the real world. For example, the assumption that vulnerability is positively correlated with poverty might be an ineffective measure of wildfire vulnerability in forest communities with a large number of wealthy amenity homeowners. Some indicator research considers only economic losses or mortality and neglects other kinds of loss such as community character or cultural values that may also be meaningful to local groups (see Crate and Nuttall 2009). Indicator work is also often excessively focused on constraints and characteristics that are lacking rather than factors that contribute to the ability of groups to take action and respond constructively.

Despite these short-comings, there are good reasons to continue indicator studies at some levels. Nelson and others (2010) distinguished between general vulnerability and specific vulnerability, pointing out that indicator research is helpful in understanding vulnerability more generally. The fundamental purpose of such work is to highlight deficiencies in adaptive capacity so that initiatives can be appropriately targeted to support capacity building where necessary. Adger (2006) argued that targeting resources to specific groups or regions should be the primary purpose of indicator studies, while Hinkel (2011) suggested that indicators are only useful for identifying vulnerable entities when systems can be narrowly defined by a few variables or as starting points to future, more detailed inquiry.

### **Case Example One: The vulnerability of Australian rural communities to climate variability and change (Nelson and others 2010)**

This study combined traditional hazards impact mapping and modeling with a composite indicator of adaptive capacity to develop a nuanced picture of regional social vulnerability in Australia. The research aimed to move beyond simple metrics of vulnerability to generate information that could be used to identify and enhance transformative measures of adaptive capacity. In a three-tiered approach, historical, social, and biophysical data were combined to develop an integrated vulnerability metric. Exposure was measured through a coefficient of variation for three factors: historic rainfall, simulated pasture growth, and historical farm income data over a 10-year period (1996/1997 to 2005/2006.) These factors were modeled out to 2030 to project impact of climatic changes in rainfall, pasture, and income. The second step involved developing an adaptive capacity index, which was constructed using the rural livelihoods analysis. This analysis framed adaptive capacity as an emergent property of diverse forms of human, social, natural, physical, and financial capital central to rural livelihoods and the flexibility to substitute among capitals in response to stressors. The results of both stages were then spatially presented using GIS to determine the integrated vulnerability measure determined as areas with high or moderate exposure and low to moderate adaptive capacity.

The integrated metric of vulnerability showed a vastly different spatial distribution of vulnerability as compared with vulnerability viewed simply as an impact of hazards. The integrated metric revealed that areas with high climatic variability were not necessarily those with highly variable farm incomes. This finding demonstrates capacities of different people and groups to manage for variability but also highlights the challenges associated with using simple indices of vulnerability. The way the metric is defined and calculated influences the results; this can have important implications for policy and program delivery if the metric is calibrated incorrectly or neglects critical contextual factors shaping vulnerability.

## **Case Studies**

Case study approaches attempt to uncover underlying drivers and processes leading to vulnerability or generating adaptive capacity, typically at the community or household level of analysis. Included in this context-oriented research design is a mix of data collection methodologies with a strong reliance on qualitative methods such as interviews, focus groups, participant observation, and archival analysis (see Adger and Kelly 1999; Adger and others 2002; Eriksen and others 2005). In case study research, the dynamics and causal factors generating vulnerability are traced out in ways that more closely reflect the actualities of real, on-the-ground processes. As Smit and Wandel (2006:285) stated, the central goal of this approach is “to document the ways in which the system or community experiences changing conditions and the processes of decision-making in this system (or that influence the system) that may accommodate adaptations or provide means of improving adaptive capacity.” The case study approach fits with a contextual approach, whether through an actor-orientation or systems-orientation.

Case study research builds an understanding of the dynamics and causal factors shaping vulnerability that matches the complexity found in actual communities. Case study research can also effectively trace out the ways that local places are connected to larger scales; though, it is less capable of describing larger-scale dynamics in detail. Obtaining these rich insights requires significant time and effort to conduct in-depth qualitative research. Further, case study research cannot typically be generalized to broader populations and thus is not intended to be “scaled-up” to larger regions. Cutter (2003) critiqued case studies for being overly specific and suggested that findings may not be applicable to other contexts. That said, a case study approach can provide important information for developing locally targeted adaptive strategies or programs used at the site of the research (i.e., for particular communities or national forests).

## Scenario Processes

Scenarios have become a popular communication tool in climate change research (McCarthy and others 2001). Scenarios use storylines developed from current patterns of economic, social, ecological, and cultural change to convey different plausible futures (Raskin 2005; Tompkins and others 2008; Wilkinson and Eidinow 2008; Gidley and others 2009; Hallegatte and others 2011; Ozkaynak and Rodriguez-Labajos 2010). By describing a range of plausible futures, scenarios can inform decisions about climate change adaptation in the context of uncertainty regarding exactly how local landscapes will change in response to warming trends (Parson 2008). Scenarios can be either a product (where the scenarios themselves are the research output) or a process (where the goal is to generate new knowledge and insight through the scenario process, which is used to stimulate discussion and reflection on different possible futures) (Wilkinson and Eidinow 2008). When employed in social vulnerability assessment, scenarios serve as a tool to understand how vulnerability differs across different plausible futures, how human communities respond and deal with uncertainties, and what kinds of capacities are required to respond under different scenarios. Thus, the scenarios are not the product of the research in and of themselves; they are simply a tool to help understand vulnerability.

Process-based scenarios are gaining in popularity as they focus on developing practical knowledge to aid decision-making through dialogue about plausible futures (Figure 5). These process-based scenarios (scenarios used in a decision-making or research process) are local in scale (O’Neil and others 2008) and use climate change projections to describe how local landscapes might change in response to warming trends. Studies typically utilize three to four qualitative storylines in accessible lay language to depict the range of possible changes.

Product-based scenarios can, like the indicator research previously described, be used in large-scale assessments to target and prioritize vulnerability reduction and adaptation efforts. While product-based scenarios are useful at the national to global scale, process-based scenarios work best at the community and household scale. The challenge at a more local scale is the considerable amount of work required to generate scenarios that contain enough detail to be useful for understanding social vulnerability at the level of communities and households.



**Figure 5**—Two researchers engage a group of local stakeholders in a scenario building process for southwest Colorado. Photograph by the Mountain Studies Institute.

### **Case Example Two: Vulnerability of water supply from the Oregon Cascades to a changing climate (Farley and others 2011)**

This study sought to understand how changes in the timing and quantity of streamflow into the McKenzie River Basin would shape vulnerability of water users. In particular, the authors were interested in whether existing management institutions were able to take spatial and temporal aspects of stream flow into account when responding to predicted climate changes. This study applied a “scenario as process” approach, combining historical data and modeled predictions of changes in stream flows to develop a scenario of future change that was presented to 18 interviewees from 4 key water sectors: fish habitat (U.S. Fish and Wildlife Service); flood control (U.S. Army Corps of Engineers); municipal water authority (Eugene Water and Electric Board); and recreational fishing (a guided fishing operation). Once the scenarios were developed, participants were asked to discuss the implications of these conditions for their area of concern, how they would respond to these conditions, the institutions in place to help respond to climate change, and the availability and access to relevant information related to climate change impacts on stream flows.

This study revealed high variability in the implications of changing stream flows across sectors. For example, municipal water users have a heightened sensitivity to projected alterations to streamflow as the projected decrease in timing of peak flows coincides with the peak demand, whereas for fishing guides, impacts of decreased summer flows may be offset by changes in spring flow. These vulnerabilities were mediated by both the spatial and temporal dimensions of stream flow and the varied institutional context of the actors. The authors were also able to see how decisions made by one sector would have implications for actors in other areas. Specifically, while U.S. Army Corps of Engineers has the physical capacity to offset some of the implications of decreased summer flows for other uses, its mandate to manage for flood control restricts its capacity to maintain summer flows for other uses. As the mandates are dictated by Congress, changes to these requirements are difficult. This shows how institutional constraints or decisions made by those who manage stream flows shape the vulnerability of those sectors that are highly sensitive to temporal variation in flows. By asking actors how they would respond and what would constrain their adaptation actions, the authors were also able to identify how the different institutional contexts across sectors either impede or enable adaptation.

## **Participatory Approaches**

Through stakeholder consultation and public engagement processes, participatory approaches seek local definitions of the hazards, risks, and uncertainties that pose threats and how they might manifest in locally meaningful ways (see Tompkins and others 2008). A participatory approach in a community might involve local stakeholders in developing a list of local vulnerabilities and context-appropriate means to measure these vulnerabilities. Participatory assessments often utilize both case study research and indicator assessments. Because local stakeholder involvement builds a rich understanding of local context, participatory approaches allow for the recognition of multiple, complex, and overlapping sources and determinants of vulnerability and adaptive capacity. Moreover, this kind of assessment creates the kind of “buy-in” that is necessary to move research results into management actions and policy change to reduce vulnerability and build adaptive capacity.

However, like case study approaches, results are highly contextualized and case specific and thus may not be more broadly generalizable. This poses a problem for scaling up and applying findings to other contexts.

**Case Example Three: Assessing social vulnerability: a study of  
the mountain pine bark beetle outbreak in British Columbia, Canada  
(Parkins and MacKendrick 2007)**

Using a participatory and multi-disciplinary approach, Parkins and MacKendrick (2007) conducted a social vulnerability assessment in response to a major outbreak of mountain pine beetle (MPB). The study was grounded in climate science and forest sociology and used focus groups to incorporate community perspectives into the research from an early stage. Of particular note, this study developed a framework to combine bio-physical risk factors (exposure) with community assessments of risk. Understanding how a community perceives risk can provide critical insights into its capacity and willingness to act: those with a high perception of risk are more likely to adopt voluntary adaptations and more willing to accept policies and programs targeted at minimizing risk.

At the outset, the researchers asked focus group participants to discuss:

1. Current and future social and economic impacts from MPB
2. Factors contributing to the community's adaptive capacity
3. Past hardships in the community that could influence present or future adaptive capacity
4. Community awareness of MPB
5. Organisational responsibility for dealing with social and economic impacts from MPB

Participants were selected to represent a range of economic, public agencies, forestry, health, social services, and other organizations. The findings of the focus groups were then used to develop a vulnerability framework containing four dimensions: physical, social, political, and economic. The second phase of the research gathered data from household surveys to measure the indicators of vulnerability and determined aggregate vulnerability scores under each dimension. Beyond the focus groups, the framework was configured to match available data, thus allowing flexibility within the metric.

The holistic approach adopted in this study created a framework to capture multi-dimensional nature of risks and vulnerabilities. Breaking down measures of vulnerability into political, economic, and physical exposure creates a more nuanced picture of what aspect of the system or community is vulnerable and, through doing so, identifies avenues for targeted interventions tailored to the context. For example, in the town of 100 Mile House, it was deduced that high levels of physical risk in some communities were tempered by other factors such as availability of alternative resources and high levels of trust in political actors. In combination, these factors increased the community's capacity to manage impacts and outcomes of MPB. These types of community-level assessments can provide a contextual understanding of exposure and response capacity that are obscured in regional- or national-scale analysis. Moreover, these studies are well suited to identify areas of strengths and weaknesses to target action. According to Parkins and MacKendrick, this then enables vulnerability assessments to become a tool to support action and build adaptive capacity.

## Conclusion

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Social vulnerability assessments not only fulfill the requirements of the Forest Service Climate Change Performance Scorecard, they also help national forests understand the ways in which climate change impacts on national forest lands affect nearby communities and their relationships with forest resources. Rather than thinking about single and immediate hazards and impacts (e.g., smoke from a wildfire happening right now), vulnerability assessments enable forests to consider multiple biophysical stressors (e.g., drought and fire) over longer time scales (e.g., 10 to 30 years) that affect different groups of people differently (e.g., unemployed mill workers versus wealthy retirees)

and how these stressors interact with other social processes (e.g., economic downturns or changes in water rights). Vulnerability research also illuminates the different capacities that individuals and communities have to adapt and how those capacities might be strengthened. Vulnerability research helps understand the “multiple and interacting social and environmental stressors” that create climate change impacts (McLaughlin and Dietz 2008:99). Improved knowledge of social vulnerability will help national forests engage local communities in climate change adaptation planning that benefits both ecosystems and human communities.

While this report is not intended to serve as a how-to guide to conducting vulnerability assessments, it should provide a sense of the conceptual and methodological landscape that informs such assessments and the ways in which different definitions of vulnerability lead to different methodological choices (each with their own strengths and weaknesses). Conceptual frameworks matter because they drive the way in which vulnerability, adaptive capacity, and adaptation are understood, which has implications for the conduct of research, its outputs, and the policy and management recommendations. This document should help researchers, policy-makers, and practitioners new to the field of vulnerability and adaptive capacity to understand the diversity of different methods and how they are connected to different conceptual framings. In deciding how to move forward, national forests and other public land management agencies will need to consider their data needs, budget and capacity, and adaptation plans. Research that draws on existing data as indicators of social vulnerability might serve as an initial study in the context of budget restrictions. However, where national forests want to integrate local community needs into adaptation planning, more detailed assessments utilizing case study or participatory methods might be necessary.

## References

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- Adger, W.N. 2006. Vulnerability. *Global Environmental Change* 16:268-281.
- Adger, W.N. and K. Vincent. 2005. Uncertainty in adaptive capacity. *Geoscience* 337:399-410.
- Adger, W.N. and P.M. Kelly. 1999. Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change* 4:253-266.
- Adger, W.N., Kelly, P.M., Winkels, A., Huy, L.Q. and C. Locke. 2002. Migration, remittances, livelihood trajectories and social resilience. *Ambio* 31:358-366.
- Adger, W.N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D.R., Naess, L.O., Wolf, J. and A. Wreford. 2009. Are there social limits to adaptation to climate change? *Climatic Change* 93:335-354.
- Berkes, F. 2007. Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. *Natural Hazards* 41:283-295.
- Berkhout, F., Hertin, J. and D.M. Gann. 2006. Learning to adapt: Organizational adaptation to climate change impacts. *Climatic Change* 78:135-156.
- Birkmann, J. 2006. Indicators and criteria for measuring vulnerability: Theoretical bases and requirements. In: *Measuring Vulnerability to Natural Hazards*. New York, United Nations Press.
- Brooks, N., Adger, W.N. and P.M. Kelly. 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* 15(2):151-163.
- Costa, L. and J.P. Kropp. 2013. Linking components of vulnerability in theoretic frameworks and case studies. *Sustainability Science* 8(1):1-9.
- Crate, S. and M. Nuttall. 2009. *Anthropology and Climate Change: From Encounters to Actions*. Walnut Creek, CA, Left Coast Press.
- Cutter, S. 2003. The vulnerability of science and the science of vulnerability. *Annual Association of American Geographers* 93(1):1-12.
- Davidson, D. 2010. The applicability of the concept of resilience to social systems: Some sources of optimism and nagging doubts. *Society and Natural Resources* 23(12):1135-1149.
- Eakin, H. and A. Luers. 2006. Assessing the vulnerability of social-environmental systems. *Annual Review of Environment and Resources* 31:365-394.
- Eakin, H. and M.C. Lemos. 2006. Adaptation and the state: Latin America and the challenge of capacity-building under globalization. *Global Environmental Change* 16:7-18.
- Eriksen, S., Brown, K. and P.M. Kelly. 2005. The dynamics of vulnerability: Locating coping strategies in Kenya and Tanzania. *Geographical Journal* 171:287-305.

- Farely, J. and R. Costanza. 2002. Envisioning shared goals for humanity: A detailed, shared vision of a sustainable and desirable USA in 2010. *Ecological Economics* 43(2-3):245-259.
- Farley, K., Tague, C. and G.E. Grant. 2011. Vulnerability of water supply from the Oregon Cascades to changing climate: Linking science to users and policy. *Global Environmental Change* 21:110-122.
- Fischer, A.P., Paveglio, T., Carroll, M., Murphy, D. and H. Brenkert-Smith. 2013. Assessing social vulnerability to climate change in communities near public forests and grasslands: A framework for resource managers and planners. *Journal of Forestry* 111(5):352-369.
- Gibson, C.C., Ostrom, E. and T.K. Ahn. 2000. The concept of scale and the human dimensions of global change: A survey. *Ecological Economics* 32(2):217-239.
- Gidley, J., Fien, J., Smith, J.-A., Thomsen, D. and T. Smith. 2009. Participatory future methods: Towards adaptability and resilience in climate-vulnerable communities. *Environmental Policy and Governance* 19:427-440.
- Grothmann, T. and A. Patt. 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* 15:199-213.
- Gunderson, L. and C.S. Holling. 2002. Resilience and adaptive cycles. In: *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington, DC, Island Press.
- Hallegratte, S. 2009. Strategies to adapt to an uncertain climate change. *Global Environmental Change* 19(2):240-247.
- Hallegratte, S., and others. 2011. Building world narratives for climate change impact, adaptation and vulnerability analyses. *Nature Climate Change* 1:151-155.
- Hewitt, K. 1997. *Regions of Risk: A Geographical Introduction to Disasters*. Essex, U.K., Longman.
- Hinkel, J. 2011. Indicators of vulnerability and adaptive capacity: Towards a clarification of the science-policy interface. *Global Environmental Change* 21:198-208.
- Hulme, M. 2009. *Why We Disagree About Climate Change: Understanding Controversy, Inaction, and Opportunity*. Cambridge, MA, Cambridge University Press.
- Ingold, K., Balsiger, J. and C. Hirschi. 2010. Climate change in mountain regions: How local communities adapt to extreme events. *Local Environment* 15(7):651-661.
- IPCC. 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Stocker, T.F., and others (eds.). Cambridge University Press: Cambridge, United Kingdom and New York.
- Johnson, D.P., Wilson, J.S. and G.C. Luber. 2009. Socioeconomic indicators of heat-related health-risk supplemented with remotely sensed data. *International Journal of Health Geographics* 8:57-70.
- Jones, B. and J. Andrey. 2007. Vulnerability index construction: Methodological choices and their influences on identifying vulnerable neighborhoods. *International Journal of Emergency Management* 4(2):269-295.
- Krasny, M.E., Lundholm, C. and R. Plummer. 2011. *Resilience in Social-Ecological Systems: The Role of Learning and Education*. New York, Routledge.
- Leichenko, R. and K. O'Brien. 2002. The dynamics of rural vulnerability to global change: The case of Southern Africa. *Mitigation and Adaptation Strategies for Global Change* 7:1-18.
- Leichenko, R. and K. O'Brien. 2008. *Environmental Change and Globalization: Double Exposures*. Oxford, Oxford University Press.
- Lemos, M.C., Agrawal, A., Eakin, H., Nelson, D.R., Engle, N.L. and O. Johns. 2013. Building adaptive capacity to climate change in less developed countries. In: Asrar, G.R. and J.W. Hurrell, Eds. *Climate Science for Serving Society: Research, Modeling, and Prediction Priorities*. Dordrecht, The Netherlands, Springer.
- Ligon, E. and L. Schechter. 2003. Measuring vulnerability. *Economic Journal* 113:C95-C102.
- Lynn, K., MacKendrick, K. and E. Donoghue. 2011. Social vulnerability and climate change: Synthesis of literature. Gen. Tech. Rep. PNW-GTR-838. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 70 p.
- McCarthy, J., Canziani, O.F., Leary, N.A., Dokken, D.J. and K.S. White, Eds. 2001. *Climate change 2001: Impacts, adaptation, vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Cambridge University Press.
- McLaughlin, P. and T. Dietz. 2008. Structure, agency and environment: Toward an integrated perspective on vulnerability. *Global Environmental Change* 18:99-111.
- Nelson, D., Adger, W.N. and K. Brown. 2007. Adaptation to environmental change: Contributions of a resilience framework. *Annual Review Environment and Resources* 32:395-419.
- Nelson, R., Kokic, P., Crimp, S., Martin, P., Meinke, H., Howden, S.M., deVoil, P., McKeon, G. and U. Nidumolu. 2010. The vulnerability of Australian rural communities to climate variability and change. *Environmental Science and Policy* 13(1):18-27.
- Norgaard, K.M. 2011. *Living in Denial: Climate Change, Emotions, and Everyday Life*. Cambridge, MA, MIT Press.
- O'Brien, K. and G. Hochachka. 2010. Integral adaptation to climate change. *Integral Theory and Practice* 5(1):89-102.

- O'Brien, K.L. and R.M. Leichenko. 2003. Winners and losers in the context of global change. *Annals of the Association of American Geographers* 93:89-103.
- O'Brien, K., Eriksen, S., Lynn, P.N. and A. Schjolden. 2007. Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy* 7(1):73-88.
- O'Neil, B., Pulver, S., VanDeveer, S. and Y. Garb. 2008. Where next with global environmental scenarios. *Environmental Research Letters* 3:1-4.
- Ozkaynak, B. and B. Rodriguez-Labajos. 2010. Multi-scale interaction in local scenario-building: A methodological framework. *Futures* 42:995-1006.
- Pahl-Wostl, C. 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change* 19(3):354-365.
- Parkins, J. and N. MacKendrick. 2007. Assessing community vulnerability: A study of the mountain beetle outbreak in British Columbia, Canada. *Global Environmental Change* 17(3-4): 460-471.
- Parson, E.A. 2008. Useful global-change scenarios: Current issues and challenges. *Environmental Research Letters* 3:1-5.
- Pelling, M. 2010. *Adaptation to Climate Change: From Resilience to Transformation*. New York, Routledge.
- Pelling, M., High, C., Dearing, J., and D. Smith. 2008. Shadow spaces for social learning: A relational understanding of adaptive capacity to climate change within organizations. *Environment and Planning A* 40(4):867-884.
- Raskin, P.D. 2005. Global scenarios: Background review for the millennium ecosystem assessment. *Ecosystems* 8:133-142.
- Ribot, J. 2011. Vulnerability before adaptation: Toward transformative climate action. *Global Environmental Change* 21(4):1160-1162.
- Roberts, J.T. and B. Parks. 2006. *A Climate of Injustice: Global Inequality, North-South Politics, and Climate Policy*. Cambridge, MA, MIT Press.
- Rodima-Taylor, D. 2012. Social innovation and climate adaptation: Local collective action in diversifying Tanzania. *Applied Geography* 33:128-134.
- Shackley, S. and R. Deanwood. 2002. Stakeholder perceptions of climate change impacts at the regional scale: Implications for the effectiveness of regional and local responses. *Environmental Planning and Management* 45(3):381-402.
- Smit, B. and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16:282-292.
- Smit, B., Burton, I., Klein, R.J.T. and J. Wandel. 2000. An anatomy of adaptation to climate change and variability. *Climatic Change* 45:223-251.
- Thornton, T.F. and N. Manasfi. 2010. Adaptation—genuine and spurious: Demystifying adaptation processes in relation to climate change. *Environment and Society* 1:132-155.
- Tompkins, E.L., Few, R., and K. Brown. 2008. Scenario-based stakeholder engagement: Incorporating stakeholders preferences into coastal planning for climate change. *Journal of Environmental Management* 88:1580-1592.
- Tschakert, P. and K.A. Dietrich. 2010. Anticipatory learning for climate change adaptation and resilience. *Ecology and Society* 15(2):11.
- Tucker, C., Eakin, H., and E.D. Castellanos. 2010. Perceptions of risk and adaptation: Coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change* 20:23-32.
- Vincent, K. 2007. Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change* 17:2-24.
- Wall, E. and K. Marzall. 2006. Adaptive capacity for climate change in Canadian rural communities. *Local Environment* 11(4):373-397.
- Wilbanks, T. and R.W. Kates. 1999. Global change in local places: How scale matters. *Climatic Change* 43:601-628.
- Wilkinson, A. and E. Eidinow. 2008. Evolving practices in environmental scenarios: A new scenario typology. *Environmental Research Letters* 3(4):1-11.
- Wisner, B., Blaikie, P., Cannon, T. and I. Davis. 2004. *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. New York, Routledge.
- Yohe, G. and R.S.J. Tol. 2002. Indicators for social and economic coping capacity: Moving toward a working definition of adaptive capacity. *Global Environmental Change* 12:25-40.
- Young, K.R. and J.K. Lipton. 2006. Adaptive governance and climate change in the tropical highlands of Western South America. *Climatic Change* 78:63-102.
- Zahran, S., Brody, S.D., Vedlitz, A., Grover, H. and C. Miller. 2008. Vulnerability and capacity: Explaining local commitment to climate-change policy. *Environment and Planning C: Government and Policy* 26(3):544-562.



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