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Assessing Social Vulnerability to Climate Change in Human Communities near Public Forests and Grasslands: A Framework for Resource Managers and Planners

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Public land management agencies have incorporated the concept of vulnerability into protocols for assessing and planning for climate change impacts on public forests and grasslands. However, resource managers and planners have little guidance for how to address the social aspects of vulnerability in these assessments and plans. Failure to assess social vulnerability to climate change during management planning could compromise land management agencies' adaptation strategies as well as public support for these strategies. We provide a framework for understanding and assessing social vulnerability to climate change in US public lands contexts. We describe types of information that can be used in social vulnerability assessments and ways this information can be gathered. The practical information that we provide is intended to help resource managers and planners meet current policy requirements for assessing potential impacts of climate change across diverse local social and ecological conditions for which one-size-fits-all approaches are not likely to be useful.

Keywords: climate change, social vulnerability, general, public land management, natural resource planning

The need for concrete ways to adapt management of public forests and grasslands for a changing climate is well recognized. Climate change is expected to dramatically alter the forest and grassland habitats, amenities, and ecosystem services that people value and depend on (Chmura et al. 2011, Climate Change Science Program 2008a). Increasingly, natural resource agencies are making commitments to assess and respond to climate change. For example, the US Department of Agriculture (USDA) and the US Department of the Interior (USDOI) now require agencies such as the Forest Service, Bureau of Land Management, and National Park Service to consider and assess the potential future impacts of climate change on both ecological systems and the human communities that influence, interact with, or rely on them (Salazar 2009, USDA 2010, USDA Forest Service 2011). Such efforts to encourage systematic assessment of climate change impacts by US natural resource agencies are part of a general shift toward thinking about linked socioecological systems at a variety of scales and the functioning of these systems in the face of ongoing complex processes.

One centerpiece of emerging policy efforts to assess climate change impacts is the identification and assessment of "vulnerability" to climate change. The climate change and natural hazards bodies of literature provide guidance for how to assess the vulnerability of ecological and social systems to climate change. However, although public agencies have incorporated the concept of vulnerability into protocols for assessing and planning for climate change impacts on public forests and grasslands, guidance about how resource managers should conduct vulnerability assessments and develop adaptation plans do not extend beyond a fo-

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cus on ecological resources. It appears that protocols for how to carry out assessments of *social* vulnerability or link such assessments to land management planning are scarce. At the time of the writing of this article no formal efforts to assess social vulnerability in public forest and grasslands contexts had been documented.

The lack of emphasis on social vulnerability is puzzling, given the multiple pressures climate change can exert on public lands and the human communities[1] near these lands (e.g., increasing drought, disease, and wildfires and changes in species composition). Communities in areas with large amounts of public land (as in many western states) can be disproportionately affected by changing ecological conditions on public lands because of their reliance on those lands for services (e.g., tourism and water) and commodities (e.g., timber and grazing) (Donohue and Sturtevant 2007, Magis 2010, Lynn et al. 2011). Failure to assess social vulnerability to climate change runs counter to the obligation many agencies have to consider the well-being of human communities near public lands in their management decisions (USDA Forest Service 1994, USDOI Bureau of Land Management 1994). Moreover, the ability of public agencies to manage their respective resources depends on support from communities that are intimately tied to management activities (e.g., resource extraction or recreation) as well as the wider public. Not acknowledging and communicating the implications of climate change and the management decisions intended to mitigate climate change effects (e.g., thinning to reduce stocking levels, transitioning forests to drought-tolerant species, and restricting water use) could result in a lack of public support or worse, opposition to adaptation plans. Likewise, if managers do not account for the influence of human communities on the ecological vulnerability of public lands, they risk not being able to anticipate pressures human communities may exert on the nature resources (e.g., decisions by hunters or forest product gatherers facing declines in populations of preferred species to substitute other species or engage in other activities, which may lead to new pressures on forests).

The goal of this article is to provide a framework for understanding and assessing social vulnerability to climate change in public land contexts in the United States. First, we provide background regarding the interdependencies between public lands and communities, including the influence of climate change on these interdependencies. Next we describe the primary components of social vulnerability using insights from the natural hazards and climate change literature and provide examples relevant for public lands management contexts. In the final two sections we present broad questions managers and planners can use to guide their assessments of social vulnerability to climate change and discuss types of information and approaches for gathering information that can help complete such assessments. Figure 1, which we will refer to throughout, depicts the components of vulnerability, types of information that can be used to assess vulnerability, and methods for gathering this information.

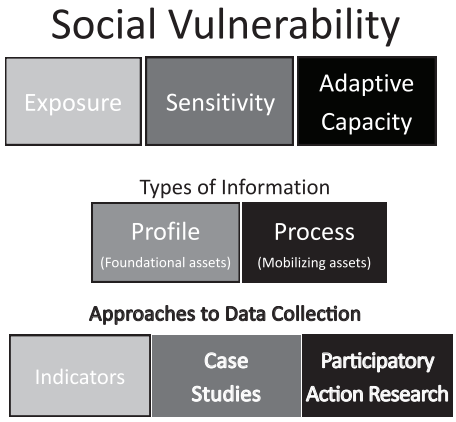

Figure 1. Primary contributions of information collection methods and information types to understanding components of social vulnerability to climate change.

Although we are aware of the ongoing debate about underlying factors and root causes leading to social vulnerability, our intent is not to explore these different lines of thought. Rather, we aim to provide a practical framework for managers and planners trying to meet current policy requirements regarding climate change across diverse local social and ecological conditions and for which a one-size-fits-all approach is not likely to be useful. The framework may also be of interest to private consultants who may conduct vulnerability assessment work for public agencies, and private landowners and other community members who may want to be informed about how public agencies are considering their needs and interests in adaptation planning.

Interdependencies between Communities and Public Lands

Concern about the relationships between ecological conditions in public forests and grasslands and the well-being of nearby communities has a long pedigree in American forestry. A main political premise for the creation of the National Forest System was linked to human communities as the practice of sustained yield forest management was intended to facilitate the creation and maintenance of "stable" human communities by replacing boom and bust towns that had been tied to the "cut out and get out era" (Pinchot 1910, Dana and Fairfax 1980). In the period after World War II, the nascent fields of forest economics and natural resource sociology sought to empirically examine the relationships between "community stability" and public forest management (Kauffman and Kauffman 1946,Waggener

Management and Policy Implications

This article provides guidance to resource managers and planners as they respond to requirements by public land management agencies to assess the potential social and ecological impacts of climate change. We provide a framework for understanding and assessing social vulnerability, including its components: exposure (the likelihood of climate-related stresses); sensitivity (the potential degree of impact to human communities); and adaptive capacity (the social conditions and processes that influence whether and how human communities prepare for or respond). We provide a set of questions that managers and planners can refer to as they consider the information they need to assess vulnerability and discuss methods to gather such information. We outline two main types of information managers and planners can assemble: "profile" information about socioeconomic and geographic conditions related to risk and stress and "process" information about social relationships and norms in a community that can influence learning and collective response. Ultimately, managers and planners will have to design social vulnerability assessments to fit the unique social and ecological conditions present in the areas they manage. However, we suggest that indicator studies, community case studies, and participatory scenario-building exercises are three well-recognized approaches for gathering profile and process information that may also be useful for assessing social vulnerability to climate change.

1977, Lee 1990). More recently, teams of researchers adopted the rubric of "community capacity" (Fortmann and Kusel 1990, Flora and Flora 1993) and "resilience" (Harris et al. 2000, Gunderson and Holling 2002) in an attempt to differentiate communities in terms of their ability to absorb and adjust to externally imposed changes such as sudden timber harvest reductions on logging communities associated with global economic trends and endangered species protection. At approximately the same time, others began to argue that human communities linked to public lands were not simply reacting to external influences but rather were active entities expressing agency on their own behalf. The traditional conceptualization of resource dependence that evolved from a primary focus on economic linkages to resource extraction (e.g., logging, mining, oil, and gas) began to incorporate the notion of emerging amenity and tourism-based economies and reflect a broader range of qualities that residents of human communities value. These range from psychic and spiritual (e.g., place attachment) to highly material (e.g., resource extraction). The relationship between public lands and communities was increasingly recognized as a reciprocal one, including a more explicit recognition of the influence that human management actions have on local ecological functioning (Beckley et al. 2002, 2008).

We contend that these expanded notions of how communities interact with landscapes constitute important considerations in the assessment of social vulnerability to climate change because such resources and linkages with local communities can be significantly affected by changing climatic conditions. Exacerbation of short- and long-term hazards such as wildfire, hurricanes, drought, and invasive species may cause shifts in vegetative communities on which human communities rely (e.g., the conversion from pinion-juniper woodlands to sagesteppe), reduced provision of ecosystems services (e.g., water for human consumption, recreation, and habitat), and declines in amenity values that drive tourism and population dynamics (e.g., populations of popular game species or types of vegetation that provide scenery). Natural resource-dependent communities may be disproportionately exposed to disturbance or climate change due to their reliance on and/or proximity to natural resources and changes in local ecosystems (Donohue and Sturtevant 2007, Magis 2010; Lynn et al. 2011). For example, communities dependent on local ecosystems for primary resources (e.g., water sources) or economic activity (e.g., tourism draws such as rafting, hiking, or biking) could be at risk for depopulation should climate change affect the local quality of life (Ford et al. 2010, Marshall 2010). As changing climatic conditions narrow the range of certain plant species, cultural reliance on vegetative communities (e.g., traditional gathering sites) could shift.

In many ways, assessing social vulnerability to climate change can be seen as an extension of existing research on forest dependence, capacity, and sustainability. Both entail efforts to understand the reciprocal linkages between changes in social systems and changes in ecological systems (Parkins and MacKendrick 2007). However, these efforts have not yet been extended to the realm of climate change.

Dimensions of Social Vulnerability to Climate Change

Social vulnerability is a cornerstone concept in social investigations of climate change and other natural hazards. Substantial research has examined social vulnerability to climate change in many international contexts (Bohle et al. 1994, Adger 1999, O'Brien and Leichenko 2000, O'Brien et al. 2004, Eakin 2005, Ford et al. 2006, 2010. Eakin et al. 2010, Marshall 2010). In the United States, research has addressed social vulnerability to climate change primarily in coastal areas prone to sea level rise (Wu et al. 2002) and disasters such as floods and hurricanes (Clark et al. 1998, Cutter et al. 2009). However, it appears that only a handful of studies examined social vulnerability to climate change and related natural hazards in forest and grassland contexts. These studies suggest that rural communities are disproportionately vulnerable to climate change or hazards such as wildfire and drought because of their dependence on agricultural, forestry, fisheries, recreation, and tourism sectors that are expected to be adversely affected (Cross 2001, Coles and Scott 2009, Karl et al. 2009, Trainor et al. 2009, Lal et al. 2011, Lynn et al. 2011).

The concept of vulnerability to natural hazards has been defined in various ways (Burton et al 1978, Kelly and Adger 2000, Allen 2003). The most common definition in the climate change literature is "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change" (Intergovernmental Panel on Climate Change [IPCC] 2001 p. 6). This definition treats vulnerability as "a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC 2001, p. 6). It refers to the geographic and socioeconomic characteristics that influence the chance of harm to human communities and human capacity to anticipate, cope with, and recover from the impact of a natural hazard (Blaikie and Brookfield 1987, Blaikie et al. 1994, Brooks 2003, Cutter et al. 2003, Wisner et al. 2004). We discuss three primary components of vulnerability: exposure, sensitivity, and adaptive capacity (Figure 1).

Exposure

Exposure is the likelihood of risks and stresses associated with or exacerbated by climate change or other hazards that could have repercussions for a community, social group, or population. Exposure can be direct (e.g., the chance of increased flooding due to severe storms or sea level rise) or indirect (e.g., the chance of longer and potentially more intense wildfire seasons due to increased temperatures, water scarcity due to reduced winter snowpack, or loss of biologically or commercially valuable species due to shift in vegetative communities) (Logan et al. 2003, Breshears et al. 2005, Westerling et al. 2006). Exposure encompasses the climate change impacts that managers would expect for a particular community given changing climatic conditions, with an emphasis on those stresses or changes that are relatively certain to occur. Exposure has been a primary focus of climate change vulnerability assessments for public land areas thus far (Climate Change Science Program 2008b, Aubry et al. 2011, Swanston et al. 2011).

Sensitivity

Sensitivity is defined as the characteristics of a system that influence the degree of impact from a stressor (Gallopin 2006, Ford et al. 2010). The sensitivity of ecological systems has been another primary emphasis of climate change vulnerability assessments in the past (Füssel and Klein 2006). The sensitivity of human communities to climate change can be influenced by geographic, social, economic, political, or cultural conditions within the community. These influences suggest economic reliance on biophysical conditions or processes that could

Table 1. Questions for managers and planners to consider when approaching climate change vulnerability assessments.

Exposure	What environmental changes or events associated with climate change may adversely affect resources that human communities rely on or derive value from?
	Which human communities rely on or derive value from resources that are likely to be affected?
Sensitivity	How may climate-related changes in local resources affect human communities' use of those resources and vice versa?
	Which segments of human communities will be disproportionately affected and why?
Adaptive capacity	What capabilities do human communities have for adapting to or mitigating climate change-related impacts?
	What opportunities exist for human communities to learn to become more capable of adapting?

be altered by climate change, cultural reliance on plant or animal species, sites, land uses, aesthetic landscapes, and ways of living that may be exposed to climate change-related impacts (e.g., drought, hurricanes, wildfire, and flooding) (Finan et al. 2002, Vásquez-León et al. 2003, Smit and Wandel 2006, Andrey and Jones 2008, West and Vásquez-León 2008, Cutter et al. 2009, Lynn et al. 2011). For instance, a local economy tied heavily to one industry (e.g., rafting) that could be significantly affected by climate change (e.g., reduced river flows) would be more sensitive to climate change impacts than a local economy that is diversified. Likewise, in areas that will experience increases in wildfire due to climate change, community opposition to hazardous forest fuel reduction policies that stem from cultural values of "privacy" or "naturalness" may increase sensitivity to these hazards. Alternatively, significant aesthetic changes to the landscape (e.g., bark beetle infestation, drought, and wildfire) can result in residents leaving the area (Parkins and MacKendrick 2007, Travis 2007). Institutional and legal parameters that are often politicized can significantly shape the sensitivity of particular communities to climate change impacts. For instance, a Wild and Scenic River designation of a waterway or the presence of habitat for fish listed under the Endangered Species Act may restrict managers' and community members' abilities to make significant changes to riverbanks that could reduce the impact of flooding.

Adaptive Capacity

Adaptive capacity is the combination of local social characteristics and external social forces that influence whether and how human communities take action to reduce their exposure or modify their sensitivity to climate change, its related impacts, or other hazards (Walker et al. 2002, Adger 2003). Adaptive capacity reflects the ability of human communities to actively respond by modifying their social norms, behaviors, and policies to anticipate or reduce risk from climate change (e.g., water use restrictions, smart growth planning, and fuel reduction to reduce future wildfire risk and restoring riparian corridors to mitigate future flooding) (Nelson et al. 2007, Lopez-Marrero 2010). Adaptive capacity has been a lesser focus in climate change vulnerability assessments for public lands areas thus far. A number of frameworks have been offered for thinking about the concept of adaptive capacity. These frameworks stress social and institutional factors that affect availability and distribution of resources, dynamic ability to generate and apply new knowledge, capacity to make decisions and act collectively, diversity and redundancy in biological and social systems, supportive structures for decisionmaking in local institutions or governments, equity and leadership among local populations, and attachment to or understanding of local ecosystems (Adger 2003, Folke et al. 2003, Pelling and High 2005, Smit and Wandel 2006, IPCC 2007, Norris et al. 2008, Gupta et al. 2010). These factors contribute to adaptive capacity differently depending on the scale (e.g., local or national) and context (e.g., community, culture, and geographic area).

Approaches to Assessing Social Vulnerability

Clearly, a complex combination of biophysical and social conditions influence the likelihood and magnitude of climate change impacts on human communities, and the capacity of human communities to adapt. As such, social vulnerability assessments may involve the collection of diverse information about social systems and diverse methods for gathering this information. Nevertheless, managers and planners facing the complex task of vulnerability assessment can focus on a small set of key questions that may help direct them to the types of information necessary for understanding social vulnerability in their area and how this information can be efficiently and effectively gathered. Table 1 presents this small set of key questions to guide gathering of the type of information that may facilitate understanding of social vulnerability in relation to human communities near public lands. Each question in the table is associated with a component of vulnerability as discussed above. The following two sections then describe the different types of information and methods for gathering information that can help answer the questions provided in Table 1.

Types of Information for Use in Social Vulnerability Assessments

Information about potential exposure, sensitivity, and adaptive capacity with regard to climate change impacts falls into two primary categories: information about the physical, social, economic, and political conditions or resources in a community and information about the social relations and processes in a community. Donohue and Sturtevant (2007) refer to these two types of information as foundational assets (i.e., resources present in a community) and mobilizing assets (i.e., social processes and relations). We employ a similar organizing language offered by Beckley et al. (2002), who distinguish between these two types of information as "profile" and "process" information (Figure 1).

Profile Information

Profile information refers to basic sociodemographic, economic, and ecological data that can be used to describe the social characteristics of a community. Profile information is typically primary data collected through survey methods (e.g., phone, mail, and documents) at the national, state, and county scales (although sometimes also at finer subcounty scales). Profile information is typically quantitative, e.g., average educational attainment and income, proportions of the population employed in economic sectors, counts of organizations and likelihoods of natural hazard events. As Beckley et al. (2002) described, profile information is useful for "illustrating how things are" and help describe a community situation at a given point in time.

Profile information about exposure of communities to climate change could in-

clude likelihoods of natural hazard events, estimates of private structures proximate to hazardous forest fuels prone to wildfire, drought projections that account for local human uses of water and rates or recharge, or simulations of changing forest composition and its effects on local timber markets. County and city planning divisions, emergency management, and disaster response agencies may be sources of information about the proximity to climate change-associated hazards and risks. Quantitative models have been developed by universities, research centers, and public agencies to provide information about exposure at scales that may be relevant for social vulnerability assessments in relation to public forests and grasslands (e.g., watersheds). However, this information does not necessarily address the potential impacts of biophysical changes on local communities (e.g., the effects on the local tourism industry, timber markets, and community members' and stakeholders' connections to the landscape).

Regarding sensitivity, profile information indicating economic reliance on resources potentially affected by climate change could include data such as employment rates in a forest product sector focused on a drought-intolerant species or tourism sector emphasizing river use. Profile information indicating cultural reliance on land-based resources could include proportion of the community population that derives a livelihood from forestry or ranching or uses various resources for cultural practices such as those of many Native American groups. Profile information reflecting access to resources could include rates of poverty, unemployment, income, educational attainment, employment in different sectors, or proportions of the population identifying with marginalized racial and ethnic groups. The US Census Bureau, which administers the US Census and the American Community Survey, is a common source for general demographic information that can be used to consider aspect sensitivity. Census Bureau data are available at scales fine enough to create a profile of a rural community (e.g., census-designated place or census block). However, there are limitations to these data, which we discuss below. Because such data exist for large populations, they can be useful in "prioritizing" vulnerable populations and communities at macro scales from county to state to region. Moreover, Census Bureau data often are geo-coded, making them particularly suited to mapping methods that allow researchers to understand societal phenomena in place. Because such methods are highly standardized, these data are relatively easy to replicate and communicate in a policy context.

Adaptive capacity is probably best assessed with process information; nevertheless, a few kinds of profile information may be worth assembling to address adaptive capacity. Financial wealth (e.g., the proportion of a community living at a poverty threshold) and political power (e.g., the size of budgets of state and local natural resource programs and the strength of political representation) may provide evidence of access to resources, and the capacity for learning may be indicated by high levels of educational attainment in a community and a diverse demographic composition, which may indicate diverse sources of knowledge and ideas to spark innovation. Again, this information is available through the US Census Bureau.

Process Information

"Process information refers to characteristics of a community that explain what people *do* rather than what they *are*" (Beckley et al. 2002, p. 631). Process information concerns the relations among people and organizations and between people and landscapes that influence people's perceptions of their own well-being and capacity to act. These constantly evolving processes give rise to a community's capacity for realizing goals and acting collectively. In the case of climate change, process information can explain the capabilities community members and institutions exhibit in the areas of learning, decisionmaking, and collective action (Flint et al. 2008, Paveglio et al. 2010). Process information is also important in understanding how trust, mutual understanding, social beliefs, values, and behaviors translate into adaptive actions. It describes historical factors influencing community adaptation to ecological hazards, social change, and risk, e.g., the relationships and history that community members have with land management agencies, their place-based attachment to the land, their experiential knowledge of the local ecology, and the ability of community members to work together and organize (Smit and Wandel 2006, Magis 2010). Put another way, process information is "useful for discovering how things came to be that way or what needs to happen for things to be different" (Beckley et al. 2002, p. 631). For this reason, process information is most critical in understanding adaptive capacity and sensitivity.

At the scale of local communities, process information is most often qualitative: counts, means, and rates do not often capture the contextual information that is important for describing social processes. For example, quantitative information is generally not useful for understanding social and institutional relationships that foster trust, fairness, mutual understanding, learning, and collective action. Process information may be different for each community, as the relationships, histories, and ongoing interactions local people have with the land and each other may be site-specific. Therefore, process information is typically collected as primary data (e.g., through interviews or observation) about the norms, behaviors, and beliefs of local people. Managers should understand that their experience with and inquiries about the community in question and their judgments about the local political, social, and cultural climate as they relate to support for or ability to collaborate on natural resource management, are very important in identifying process characteristics. Such local insights are also crucial in understanding whether a given social vulnerability assessment will accurately predict the sensitivities and adaptive capacity of local people to reduce their impacts from climate change.

A firsthand qualitative understanding is critical for understanding adaptive capacity, but existing data sets can provide introductory insights on social processes. For instance, information about the diversity of civic organizations and rates of volunteerism, census participation, and voting in a community can suggest capacity for fostering access to resources, facilitating the communication of knowledge and exchange of ideas and, ultimately, self-organization and collaboration (Carpenter et al. 2001). Evidence of organization and civic engagement can be found in data sets such as the American Communities Survey and the General Social Survey and in collections of state- and county-level social capital indicators (Putnam 2001, Rupasingha et al. 2006). Local government agencies may also be able to furnish information that provides evidence about norms of cooperation in the area of natural hazards, e.g., levels of participation in fuel reduction, vegetation management, and flood mitigation programs; rates of local organizational involvement in hazard response; levels of volunteerism in local natural resource organizations and programs; counts of specialized planning groups or or-

ganizations aimed to manage climate change impacts; percentages of individuals engaged in adaptation behaviors; or the existence of planning documents or policies designed to mitigate climate change-related impacts (Cutter et al. 2008a, Posey 2009, Preston et al. 2011). Such planning documents (e.g., hazard mitigation plans and comments on environmental impact statements) may provide insight into local perceptions of resource management and willingness to accept local impacts from disturbances.

Ultimately, uncovering critical aspects of sensitivity and adaptive capacity entails managers using their knowledge about the local culture and context and managers' ability to work collectively with community members to gain a better understanding of their capabilities for reducing exposure and sensitivity to climate change impacts. Information about previous actions conducted by the community (e.g., shifts in the local economy, support for or opposition to natural resource management, and hazard mitigation) can also help provide this insight, as can directed conversations with or surveys of community members about their perceptions of their existing capabilities and understanding of climate change impacts and potential impacts on community well-being.

Both profile and process information has a place in assessments of social vulnerability to climate change. We now turn to a discussion of three common approaches for the collection of profile and process information and the relative merits for managers and planners conducting social vulnerability assessments in the context of public lands in the United States.

Approaches to Collecting Information for Social Vulnerability Assessments

Although a wide variety of approaches could be considered for conducting social vulnerability assessments—from creating a very simple profile of a community to developing a quantitative computer model of linked human and ecological processes—fewer approaches offer a balance between complexity and practicality. Increasingly, mixed-method approaches are being used to collect and assess vulnerability (Norris et al. 2008, Longstaff et al. 2010, Hinkel 2011). Here we discuss three common approaches for collecting profile and process information as part of social vulnerability assessments that may be useful and practical for resource managers and planners: the use of indicators, which involve assembling profile information using secondary data; case studies, which involve the use of existing profile information and gathering process information firsthand from communities; and scenario building, a participatory approach that engages social processes and builds social relationships (Figure 1). In the following subsections, we discuss the strengths and weaknesses of these different approaches, highlighting their respective ability to address the three components of vulnerability (exposure, sensitivity, and adaptive capacity) as well as the kinds of information they provide (profile or process).

Indicators

Indicators are simple measures, generally quantitative, that provide insight into complex conditions. Indicators are often crafted from profile information such as income levels, educational attainment, and other population characteristics that have been collected in the past through surveys such as those of the US Census Bureau. Indicators provide a snapshot of a community through the lens of a few select attributes. Social vulnerability indicators or indices (composite measures) can include both social and biophysical data regarding vulnerability to climate change stressors (Cutter et al. 2003, 2008b, 2009, Andrey and Jones 2008). Managers and planners may also choose to construct their own indicators using locally available profile information. What indicators lack in detail and richness, they attempt to make up for with efficiency. The information used to construct indicators is generally available on course scales and across broad geographic areas, which make indicators useful for large-scale targeting efforts and typically cost-effective. Combined with data on the probabilistic occurrence of a natural threat or climate change impact, indicator-based studies can provide a broad sense of a community's exposure, sensitivity, and capacity to adapt to climate-related hazards and changes.

Despite the efficiency of indicators, several notable weaknesses need to be understood. First, the range of available indicators is limited by the small set of variables that are commonly and widely collected. In addition, few indicators provide insight at local scales or in rural communities. Rather, indicators are more representative of human populations at county and state scales. Some controversy exists about methods for "weighting" the variables that contribute more or less to vulnerability and peoples' ability to respond through adaptation (Eakin and Bojórquez-Tapia 2008, Hahn et al. 2009, Hinkel 2011). Substantial debate also exists over the extent to which indicators can be generalized or applied to all groups of people and hazards. For example, studies of social vulnerability have made claims that sociodemographic attributes such as poverty, single parent households, aging local infrastructure, and minority status can increase populations' vulnerability to natural hazards (Morrow 1999, Cutter et al. 2008a). However, these claims are not consistent or sufficient to predict observed variability in vulnerability influences or impact due to hazards or climate change (Tierney 2009, Preston et al. 2011). These measurement issues highlight concerns about simplifying complex phenomena such as vulnerability. Therefore, relying solely on indicators can lead managers to miss important facets of complex human-ecosystem relationships.

Community Case Studies

Community case studies provide a flexible approach for assessing social vulnerability that draw on locally available information and resources without requiring substantial investments or expertise. Case studies examine phenomena (e.g., social vulnerability to climate change) in a particular context using multiple sources of information for the purposes of triangulation (Robson 2002). The case study approach allows managers and planners to consider the local context and rely on their own expertise, experience, and familiarity with the communities in question when deciding which types of information to incorporate into vulnerability assessments.

Creating an initial profile of a community by assembling existing information from local sources or broader databases (e.g., probabilities of conditions or events; proximity to natural hazards; income, educational attainment, and employment levels; and rates of voting and membership to civic organizations) can be a useful first step in a community case study. However, what gives a case study its explanatory power is the collection of profile and process information directly from local primary sources (e.g., interviews, focus groups, participant observation with individuals or organizations, records collections, newsletters, and other local publications). Field-based methods such as interviews, participant observation, or focus groups allow researchers to collect this information at fine scales relevant to the units of land on which management and planning is occurring. Thus, the data col-

lected through case studies may provide more insight regarding local social processes and in-depth understanding of relationships between social and ecological systems (i.e., how changes in a resource may affect a resource-dependent community or different social groups within a community). In this respect, case studies provide more opportunity than indicator approaches for collecting information about the nuanced drivers of vulnerability such as equitable access to resources, capacity for learning, and norms of cooperation, which contribute to adaptive capacity. Another benefit of case studies is that they can engage community members directly in the collection and interpretation of data, thus fostering reflection, cooperation, and learning within a community, which can help build adaptive capacity (Fernandez-Gimenez et al. 2008, Flintet al. 2008).

Although able to yield great detail and nuance, case studies can present some limitations. The work itself can be time-intensive and thus expensive to undertake. Moreover, social processes easily observed and described by field methods often constitute phenomena that are not easily measured or generalized. In other words, case studies often sacrifice external validity (i.e., how well a case study represents other cases) for internal validity (i.e., how well a case study describes a particular case). In this sense they give managers a good understanding of sensitivity and adaptive capacity in a particular context but not necessarily of relative vulnerability more broadly. For these reasons, it can be difficult to translate data from case studies into policy recommendations for broad socioecological landscapes (e.g., regions). Some of these issues can be addressed through the sharing and comparison of insights developed through social vulnerability assessments of similar communities. Such comparisons can yield a better approximation of external validity and provide more broad-scale policy implications.

Participatory Scenario-Building

Participatory scenario-building brings people with scientific expertise and experiential knowledge together to understand drivers of change and implications of current behavior to illuminate possible future conditions (Peterson et al. 2003, Nassauer and Corry 2004). Scenario-building is an appropriate approach to anticipating future change and associated impacts when the phenomenon at hand is highly complex and outcomes are uncertain. Climate change is such a phenomenon (Olsson et al. 2004, Lemos and Agrawal 2006).

Generally, scenario-building engages stakeholders (e.g., community members and leaders, biophysical and social scientists, managers and planners, and policymakers) in a series of steps for understanding vulnerability and conceiving alternative courses of action to reduce impacts. A first step is for stakeholders to collectively identify the overarching problem (i.e., potential impact) and range of conditions and drivers contributing to the problem. A next step is for participants to consider successive "what if" scenarios and their implications, drawing on existing knowledge and insights about who or what might be affected by climate change impacts and what can be done in response, given the community's adaptive capacity. Finally, stakeholders are engaged in the identification of alternative courses of management and policy (i.e., scenarios) and their potential impacts on both social and ecological systems.

A benefit of scenario-building is that it can be conducted at different scales and with various levels of rigor, from informal focus group-based discussion of conceptual models of change to highly formal decision analysis and computer-based modeling. Particularly for the former, scenario-building can be cost-effective both in funding and time. Another benefit of scenario building is that it can serve as a process for learning by helping to build and promote cooperation among diverse social groups, organizations, and networks that are highly relevant locally (Fabrice 2000). When computer-based scenario-building is combined with an indicator approach, scenario models can help illustrate graphically (i.e., maps) the potential distribution of exposure and generalized sensitivities of communities under different climate change projections. However, such sophistication and complexity is not required for scenario-building to be useful. A drawback of scenario-building as a social vulnerability assessment tool is that the results, as with the case study approach, are difficult to compare across cases. Scenario-building also is potentially time-consuming when conducted at larger scales or when it requires scheduling and facilitating meetings of various groups of people with differing types of knowledge. Likewise, quantitative modeling of indicators, drivers, or biophysical exposure to climate change impacts can require technical skills, experience, and time that managers may not have.

Conclusion

Public land managers and planners have long been concerned with the issues surrounding the relationship between communities and national forests. Climate change and the myriad of socioecological stresses it can create or exacerbate demands more deliberate approaches to understanding this relationship. More specifically, additional understanding is needed regarding how human communities, including residents and private landowners near public lands, may be affected by climate-related changes and how these communities might be able to modify their sensitivity or exposure to those impacts in the future. Social vulnerability is an outgrowth of the earlier notions of resource dependence and community capacity to act in response to social or ecological change. Although social vulnerability can be a useful concept for natural resource managers and planners assessing the potential impacts of climate change, little guidance or insight has been provided into why this is the case or how they might go about conducting such assessments. To that end, this article offered a framework for understanding and assessing social vulnerability that can help guide managers and planners involved in climate change adaptation planning. The framework may also be of interest to private consultants conducting vulnerability assessments for public agencies and private landowners or other community members who may want information regarding how public agencies are considering their needs and interests in adaptation planning. We provided a set of questions that managers and planners can consider as they prepare to gather information to assess vulnerability. We also discussed different types of information and approaches to gathering it. Ultimately managers and planners will have to design social vulnerability assessments to fit the unique social and ecological conditions of the areas they manage. However, working toward a common understanding of social vulnerability and how to assess it may help managers and planners conduct social vulnerability assessments that are comparable across geographic areas and scales.

Endnote

1. Our effort to discuss the assessment of social vulnerability to climate change uses the term *community* loosely to refer to groups of people in geographic areas near public forests

and grasslands including settlements, towns, and counties.

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