

Chapter 9.3—Sociocultural Perspectives on Threats, Risks, and Health

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Summary

Sociocultural perspectives on threats, risks, and health are explored in this chapter. The authors begin with a discussion of the linkages between well-being in the Sierra Nevada ecosystem and public health and well-being to set the context of socioecological resilience. This is followed by a summary of how trust and confidence influence the management of threats and risk. Selected ecosystem dynamics and threats of specific concern in this synthesis are discussed, and include climate change, wildland fire, and invasive species. The chapter closes with a discussion of research findings on decisionmaking related to threats and risk.

Introduction

This chapter examines the intersections of human and ecological health, and the anticipated impacts of ecosystem dynamics and threats in the Sierra Nevada and southern Cascade Range. By following the chapter on ecosystem services with this discussion of linkages between ecological and human health, we hope to further illuminate the importance of socioecological resilience and using an adaptive management approach. Common to these dynamics are varying degrees and kinds of uncertainty. For example, expected changes in precipitation are very important, but still highly uncertain (see chapter 1.4, “Synopsis of Climate Change”); predicted increases in temperature will have not been experienced by societies; and the combinations of fire and climate regimes may be entirely novel. Because such changes are uncharacteristic of past patterns, readiness to identify, adapt to, and mitigate newly recognized impacts to socioecological systems will be essential to effective management for resilience. Confronting novel conditions will pose a challenge for management and social systems to respond, because trial-and-error learning may not have occurred under comparable conditions (Schoon and Cox 2011). The need to address uncertainty heightens the importance of trust, confidence, and decision-making. These topics are highlighted as factors that may have significant influences

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on effective management of risks and threats. This chapter presents selected findings surrounding risk perception and risk management. These are anchored with examples of how findings may improve risk management into the future.

How Sierra Nevada Ecosystem Health Is Related to Public Health and Well-Being

The importance of the interaction between environmental and social health has been increasingly recognized in scientific endeavors to promote quality of life. Connections between human health and forests hold great potential for improvement of well-being (Karjalainen et al. 2010), and understanding the linkages can greatly aid efforts to conserve and restore forests (Hernández et al. 2012). By emphasizing the value of healthy ecosystems for social, cultural, and economic health, managers, researchers, and stakeholders alike have an opportunity to effectively frame why actions to protect or restore an ecosystem are valuable investments. This approach may facilitate larger scale discussions of how decisions within the forest boundary may influence issues of human health and quality of life well outside of the forest boundary.

Given projections of the diversity of cultures and accompanying diversity of values that will continue to characterize visitors and residents in the Sierra Nevada and surrounding areas, engaging stakeholders in an ongoing and adaptive process for forest management practices and decisionmaking is important. Chapter 9.1, “Broader Context for Social, Economic, and Cultural Components,” introduced the benefit of recreation and tourism in aiding the development of connections to place, among myriad other benefits. Dialogue with stakeholders, including forest community residents, can help in the identification of valued ecosystem services. In addition, discussions of valued services can facilitate stakeholder recognition of benefits they may not be aware of or value (Asah et al. 2012). Dialogue with stakeholders also reveals perceptions of what characterizes different attributes of a healthy forest and management actions required to achieve it (Sulak and Huntsinger 2012). Over time, these dialogues may result in shared meanings among participants surrounding forest health, as seen in an adaptive management process in the Sierra Nevada (Sulak and Huntsinger 2012).

Long-term residents and newcomers alike find value in ecosystem quality and resilience for a variety of reasons, as may those who have no residency ties but have formed other connections to place (Kaltenborn and Williams 2002).

Rural communities in the Sierra Nevada have experienced significant political, social, economic, and environmental transitions (see box 9.3-1). As these transitions have occurred, economic well-being in a number of Sierra Nevada communities has drawn increased attention. Though much attention has been paid to poverty in urban

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areas (owing in part to the large proportion of populations in those locales), poverty in rural areas has received less attention. Examining rural communities in the Sierra Nevada synthesis area offers the opportunity to assess connections between poverty and well-being and linkages to ecological quality, short and long term. Identifying these linkages reveals the layers of multiple threats facing Sierra Nevada communities.

Box 9.3-1

Sierra Nevada Community Well-Being

Transition in Sierra Nevada communities was discussed in a Sierra Cascade dialogue session (#3, held October 12, 2011). Jonathan Kusel, Ph.D., offered evidence that rural communities in the synthesis area were hit especially hard by the recession. His analysis suggests that communities are losing families with young children, the average age in remaining populations is increasing, and the middle class is migrating away from the area. He described community services, including health services, as being drained, and he highlighted the need for infrastructure reinvestment.⁴

Additional assessments of well-being are provided on an annual basis by the University of Wisconsin, Population Health Institute and the Robert Wood Johnson Foundation.⁵ Multiple factors of well-being are ranked at the county level for most counties in the Nation. Examining the rankings for the state of California shows several counties that overlap in whole or in part with the assessment area that are doing poorly across a number of outcomes they assessed. The indicators used for well-being may be of value in measuring socioecological resilience in the Sierra Nevada and southern Cascade Range.⁶

⁴ Notes from this Dialog Session are available upon request from Patricia L. Winter, Pacific Southwest Research Station, 4955 Canyon Crest Dr., Riverside, CA 92507.

⁵ Available at <http://www.countyhealthrankings.org>.

⁶ Booske et al. (2010) outlined the assignment of weights and assessment of determinants of health underlying the rankings.

Evans et al. (2009) highlighted the experiences of rural youth living in poverty. These youths typically experience more day-to-day stressors than their middle-income counterparts. Evans et al. (2009) also reported that the greatest number of low-income American children and youth are white, and they are disproportionately represented in rural areas. Economic stressors in the Sierra Nevada suggest that some communities may be of particular concern. Evans and Rosenbaum (2008) documented generational impacts of poverty that are longstanding and affect

cognitive and socioemotional processes, influencing life-long development and outcomes in adulthood. Evans and Kim (2010) connected multiple environmental and social risk exposures to socioeconomic status, highlighting the importance of understanding that poverty is typically linked to additional social risks as well as environmental risks. Evans (2006) provided linkages between childhood development and environmental quality, pointing to the importance of ecological health in proper development of future generations.

These findings are applicable to fostering socioecological resilience because environmental condition affects development, environmental quality and opportunity are linked to community and economic resilience, and poor environmental and economic conditions impose immediate and long-term impacts on generations of youth. The cumulative risk assessment framework presented by deFur et al. (2007) is helpful in understanding issues of individual exposure to risk, impacts of cumulative risks upon the same individual, and individual and community resources available to respond to risk. Their framework echoes back to the theme of socioecological resilience, as it pairs human and ecological systems and the multiple risks each is exposed to as a way to conceptualize vulnerability and understand well-being. deFur et al. (2007) also emphasized the multiple scales necessary in understanding vulnerability and response to risk. They outlined “receptor characteristics” that include individual and group qualities as well as environmental considerations or habitat qualities. Among receptor characteristics are biological factors (e.g., genetics and life stage), psychological factors (e.g., mental health and activities, including physical activity), and social factors (e.g., socioeconomic status (SES) and population size). Habitat quality includes location (e.g., rural vs. urban and time indoors vs. outdoors), quality of setting (natural, built, and social environments), and resources (e.g., social capital and system complexity). deFur et al (2007) pointed out that discussions of resilience need to consider how some factors, for example SES, cut across both individual and environmental conditions. Additionally, they emphasized the importance of psychological and social factors, essential to human populations but not typically examined in treatments of vulnerability and resilience. Receptors at the group level include community, and would then consider aspects of community resilience.

A later chapter of this synthesis (9.4) addresses community resilience and management approaches to contribute to community resilience; however, it is useful to point out here that the current and future well-being of human populations in the Sierra Nevada is directly linked to an array of influences, including resilience of the Sierra Nevada ecosystem and its biophysical components, as discussed in earlier chapters.

The increasing cultural diversity within the synthesis area is an additional factor in risk management, vulnerability, and resilience, because the different ways that risk is perceived and acted upon by individuals are influenced by culture (Earle and Cvetkovich 1999, Lindell and Perry 2004). Diversity requires the ability to understand and take into account increasingly complex value sets, relationships to the synthesis area, and relationships among social groups and institutions.

Another significant factor is the issue of environmental justice (Greenberg et al. 2012), including consideration of differential exposure to risks and subsequent differential impacts of exposure, the ability of vulnerable communities to adapt to or mitigate risk, and effective approaches to working with communities in communicating and addressing risk. For example, communities believed to be most vulnerable to the effects of climate change on forest lands are the young, elderly, and minority communities; rural communities with strong ties to natural resource amenities (including those offering recreational opportunities); and Native American or tribal communities (Krishnaswamy et al. 2012, Wear and Joyce 2012). Specific examples of the link between social and environmental health within the Sierra Nevada are represented in other chapters in this synthesis. Chapter 8.1, “Air Quality,” presents a series of studies pointing to elevated ozone levels that exceed public health standards, thereby presenting a direct risk to health. This elevated risk has been identified in multiple locations in the Sierra Nevada, especially on the western slopes downwind from pollution sources in the California Central Valley. Poor air quality is of special concern in a number of ways. Year-round residents situated in areas with documented high concentration levels, or residents who frequently travel to those areas in their local surroundings or take short distance day trips to nearby locations, are exposed to elevated ozone concentrations. Given the temperate climate during most months, and the natural amenities surrounding year-round residents, it is likely that residents spend a portion of their time outdoors and therefore have a greater exposure than if they were indoors most of the day. Sensitive populations that would be more adversely affected by poor air quality include the elderly, the very young, and those with respiratory conditions classified as chronic obstructive pulmonary disease.⁷ Additional concerns for the recreating public are also worthy of note, as much of the Sierra Nevada is a prime recreation and tourism destination. Recreationists engaging in more physically exerting activities, such as hiking or mountain biking, would be of greater concern than those relaxing or enjoying more stationary activities. It may be prudent to warn the recreating public about the risks associated with increased ozone in the southern

⁷For a discussion of threats to human health from ozone, see <http://www.epa.gov/apti/ozonehealth/population.html>.

Sierra Nevada during the summer season (Cisneros et al. 2010). Discussions of air quality issues in forests offer additional insights into issues surrounding the public and risk associated with air pollution (see Winter 1999).

Aside from the commonality of uncertainty, overarching influences are found among studies of trust and confidence, as well as studies of decisionmaking. These topics are highlighted in order to point to factors that can have significant influence on effective management of risks and threats, not only of the specific threats examined in this chapter, but the array of issues and concerns addressed in prior chapters.

Understanding Trust and Confidence

The ability to effectively communicate with publics about current and anticipated risks and to effectively manage forest lands to decrease adverse impacts of risk-related events is influenced by myriad factors, including trust and confidence that the public has in land management agencies. Trust has been discussed in many ways regarding natural resource management, and has also been measured in many ways. This chapter cannot characterize the full range of these variations, but the following discussion summarizes some of the key findings surrounding trust and distrust, as well as some of their implications.

According to Levi (1998), trust has multiple characteristics, including a willingness to believe that another has an incentive to act in ways consistent with one's own interests, leading to an initial evaluation of trustworthiness. Trust maintenance depends on finding this perceived trustworthiness is confirmed, or trust will be withdrawn. A determining factor in the initial and ongoing basis of assessment of trust may rely on a perception of similar salient values (including goals, thoughts, views, and direction) (Earle and Cvetkovich 1995, Vaske et al. 2007, Winter and Cvetkovich 2008). Others have discussed the influences of perceived competence and fairness in assessment of trust (Levi 1998). These may be based on implicit and intuitive processes, or derived from explicit and knowledge or fact-based processes (Cvetkovich and Winter 2007). When based on explicit processes, judgments can be derived from direct or indirect experiences (e.g., through relationships), through reliance on external governing policies or regulations, institutionalized accountability, and opportunities to express one's views (Cvetkovich and Winter 2007). These are sources of what have been referred to as relational assurances, and include confidence. Therefore, there are myriad bases from which trust judgments may be derived, and recommendations to build and maintain trust must be crafted with care to avoid oversimplifying the dynamics of trust.

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Care must also be taken in discussions of trust because there has been a great deal of confusion over operational definitions, where measurement of other concerns, such as perceived competence, have been used interchangeably with trust but ultimately are not complete determinants of trust. Assumptions of distrust have been made when stakeholders have shared stories of concern or mishap in interactions with individuals or representatives of agencies; however, when both quantitative and qualitative approaches are combined, it is often apparent that trust is present, and problems have been presented as stories of exception (Winter and Cvetkovich 2013). Research demonstrates that individuals give notable focus and consideration to processing of negative information, thus qualitative measures alone may be contrived as representative of the absence of trust or outright distrust when individuals are merely revealing cognitive and social properties of the treatment of negative information (Pidgeon et al. 2007, Winter and Cvetkovich 2013).

In addition to the components of trust, the nature and impacts of trust have been examined. For example, Levi (1998) points out that although many suggest trust is always desirable and of high value, distrust may in effect be equally functional in serving the public good. Distrust is functional where decisions and actions are carefully evaluated and scrutinized, and thus must meet a higher standard of validation and transparency. Distrust can also foster consideration of alternatives and reasons behind a course of action that is selected. The sociopolitical environment in California—which includes political distrust, and a trend toward civic disengagement—portends greater rather than less difficulty in reaching public consensus on policy issues (Baldassare 2000). These trends are not constrained to California (Löfstedt 2013), and in some cases, they reflect a detachment, disconnection, and mistrust of anything “governmental” by a segment of the public best characterized as angry or “fed up” (Susskind and Field 1996). However, larger trends of trust or distrust in agencies or government do not directly translate into trust or distrust of the Forest Service or its employees directly involved in management within the synthesis area. For example, Bowker et al. (2008) reported that the majority of respondents to a national survey trusted land managers to select the best methods for dealing with wildfire.

A number of studies have revealed relatively high levels of trust across a number of management issues involving the Forest Service, though these have been paired with an identification of other factors that are influential in public response to agency actions and proposed actions, including knowledge, personal experience, and degree of personal impact versus impact to others (Winter and Cvetkovich 2013).

Furthermore, trust in agencies or individuals may be relatively resilient, even when actions are taken that appear inconsistent with values (Winter and Cvetkovich 2013). In such cases, careful communication of reasons for value-inconsistent action or actions and decisions that seem counter to shared objectives can be beneficial in establishing legitimacy (see, for example, Cvetkovich and Winter 2007, Winter and Cvetkovich 2008). Predicting how people will behave based on their stated trust levels yields mixed results. It is often assumed that trust encourages people to collaborate on important natural resource management issues, but it is also quite possible that distrust brings participants into collaborations and keeps them actively engaged in order to allow direct monitoring of personal or group interests (Levi 1998). Others may feel little need to be actively engaged if trust is present, relying on managing agencies to make appropriate decisions (Winter and Cvetkovich 2013).

Confusion over outcomes of trust surrounding natural resource management comes from a partial understanding or misunderstanding of the distinction between generalized trust and public response to specific proposed actions or decisions. Trust is, in essence, situation-specific; thus, though general trust may be present, specific trust related to a proposed action can evoke a specific response that seems contradictory to this aforementioned general trust (Winter and Cvetkovich 2013). Likewise, general attitudes do a poor job of predicting specific behaviors (Gifford and Sussman 2012); therefore, interacting in broad terms and gaining agreement on general direction or goals for management, for example, may ultimately prove disappointing when actions in a specific location are carried out. Behavior is influenced by a constellation of attitudes, values, knowledge, and other factors (Gifford and Sussman 2012, Heberlein 2012), so even when individuals agree on overall goals, and trust is present, a competing attitude or issue may bubble to the surface and lead to conflict and disagreement (see chapter 9.1 for a discussion of the influences of behavior outlined in the Environmental Intervention Handbook). Recent advances in public deliberations and engagements have recognized these complexities and integrated them into collaborative processes to improve outcomes. These advances offer significant value when working in environments where values are diverse, can often conflict, and are essential to reflect on and incorporate to the degree possible in managing public resources and planning for the future of the Sierra Nevada and southern Cascade Range (collaboration methods are further discussed in chapter 9.6, “Collaboration in National Forest Management”).

Löfstedt (2013) offered recommendations for communicating scientific information regarding risks where uncertainty is involved and distrust is present. Although his analysis was specific to food risks and regulations, he offered insights that seem valuable to natural resource management and risk communication. These

include (1) strengthening communications so they can be proactive instead of reactive to help build trust; (2) providing continuing education for agency personnel in risk-related communications to improve delivery of clear and concise messages; (3) ensuring that communications are clear, consistent, fair, and balanced; (4) drawing from third-party experts in science and risk communications to optimize effectiveness of communications; (5) considering establishing risk communication advisory boards (in part to reflect on how risk-related messages will be perceived and reacted to by various target audiences); and (6) strengthening scientific expertise and promoting applicable agency science. We now turn to three specific ecosystem dynamics and threats to further explore connections between social and ecological well-being in the Sierra Nevada.

Ecosystem Dynamics, Threats and Risks

Climate Change

Public perceptions and communication surrounding climate change—

A national study of Americans revealed that there is a high level of belief that global climate change is real and is a significant concern. Nevertheless, the impacts are overall believed to affect distant peoples and lands, and to be of moderate severity (Leiserowitz 2005). This study also revealed there are two important segments on both sides of the majority opinion, including people who believe that climate change is a fabricated hoax, as well as those who believe that climate change poses extreme risks. Thus, ideas about climate change vary among the public, as they do among politicians and environmentalists (Leiserowitz 2005). Strikingly different views about the risks of climate change make it difficult to address changes at a larger scale (e.g., reducing the demand for water if climate change leads to reduced supply) (see Das et al. 2011 and Shaw et al. 2011 for discussion of impacts referred to in this example).

Maibach et al. (2008) suggested that tailoring messaging and outreach efforts to address this diversity of viewpoints and values will increase the chance of changing behavior and policy to address climate change (see box 9.3-2). Addressing these diverse viewpoints and values is essential to bridging perceptual divides and increasing understanding of climate change impacts, and generating support for the actions needed for mitigation and adaptation (Nisbet 2009).

Koger et al. (2011) suggested that framing climate change as a global environmental issue may make it distant or too removed from personal responsibility, thus inhibiting actions to mitigate impacts. They suggested reframing climate change to focus on the immediacy and local nature of issues and impacts, and emphasizing behavioral control and actions that are problem focused. They also suggested

Box 9.3-2

Public Perceptions of Climate Change

A recent study in California demonstrates the ongoing complexities of public perceptions of climate change and its impacts. A majority or near majority of Californians are very concerned about possible impacts of global warming in the state, which include more severe wildfires (56 percent), increased air pollution (48 percent), and more severe droughts (45 percent) (Baldassare et al. 2011). A majority believe the effects of global warming have already begun, and it is necessary to take steps to counter the impacts right away. However, global warming is not among the top five most often mentioned environmental issues in California. Air pollution remains the top issue for Californians in the most recent statewide survey (27 percent), followed by water pollution (8 percent), water supply (8 percent), and energy (7 percent) (Baldassare et al. 2011).

Elke Schuster



Figure 1—View of Lake Isabella and surroundings from Highway 483 in Havilah, a community near the Sequoia National Forest.

emphasizing the public health issues involved, and the health benefits of preserving nature, thus providing a positive rather than negative framing for promoting action.

Including information about the potential social, demographic, and economic disruptions from climate change in addition to physical health impacts broadens the consideration of well-being and represents a wider range of values that might motivate support for mitigation measures and personal behavioral changes (Bain et al. 2012, McMichael et al. 2006). Additionally, climate change is likely to affect whole groups or sectors of minority or ethnic groups differently, based on the dependence of each cultural group's traditions and livelihoods on valued resources affected by climate in different ways (e.g., for American Indians, see Voggesser et al. 2013). Impacts of climate change on rural communities are of pressing concern and currently under examination by a group of agency researchers and collaborators across the United States (see fig. 1).⁸

Related research highlights a number of effective strategies for communicating about climate change; these include anchoring climate change discussions in ways that demonstrate impact to locales specific to the target audience and peoples viewed as similar to them, as well as stressing that impacts are expected soon. It is also important to describe the certainty surrounding many of the current forecasted effects (see Spence et al. 2012). Likelihood and severity of localized impacts has also been suggested as important in the adoption of and investment in adaptation measures among agency decisionmakers (Syal et al. 2011). It is clear that uncertainty may be acceptable when the audience understands that uncertainties are part of a deeper understanding of complex mechanisms such as climate change (Rabinovich and Morton 2012). In this case, communicating the role of science, and revealing the complexities and uncertainties of impacts, is just as important as relaying findings about climate change.⁹

Impacts of climate change—

Expected impacts of climate change on tourism worldwide vary based on market segment and geographic region, but may include a decreased winter sports season, heat stress risks for tourists, risks of exposure to infectious diseases, increased competition for recreational opportunities and alternate uses dependent on water, loss of natural attractions and species in ecosystems, decreased access and compromised experiences from more frequent and larger wildfires, and changes in soils that may alter ecosystem impacts of uses (WTO and UNEP 2008).

⁸ More information about this effort can be found at <http://www.cfc.umt.edu/VAC/>.

⁹ A recent synthesis of the potential and ongoing contributions of psychology to address climate change impacts may be helpful to the reader of this report (see Swim et al. 2010).

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Morris and Walls (2009) examined climate change impacts on outdoor recreation in the United States. The anticipated lessened snowpack in the Sierra Nevada is expected to be dramatic in comparison to areas with cooler climates, and thus a significant risk to skiing and snowboarding days is expected. Although these may be addressed with improved snowmaking technologies and shifting of ski runs to higher elevations, the feasibility and financial support for such adaptations will likely vary by region (Morris and Walls 2009). Angling and sport fishing may be affected by changes in precipitation as well as reduced runoff from snowmelt. The effects are expected to be more significant in the West (Morris and Walls 2009). Declines in trout habitat and the associated socioeconomic consequences owing to climate change are discussed in chapter 6.1, “Watershed and Stream Ecosystems.”

Research has identified many local impacts of climate change, including those presented here. Maurer (2007) outlined hydrologic impacts of climate change in the Sierra Nevada under two scenarios. With expected increases in temperature, he projected an increase in winter streamflow from increased precipitation, and decreasing late spring and summer flow associated with lessened snowpack at the end of winter. These anticipated shifts will not only have impacts on demands for water management (Maurer 2007), but they will also impact ecosystem services for California communities that depend heavily on water supply from the Sierra Nevada (Morelli et al. 2011), and they will likely have impacts on spring and summer recreation and tourism, especially those activities that are water dependent.

Researchers have developed models to characterize the potential impacts of climate change in the Sierra Nevada, and these models may further aid planning and anticipation of impacts. Climate change effects on hydrology and wildfires are summarized in chapter 1.4, “Synopsis of Climate Change.” The potential for flooding effects on downstream communities for the western Sierra Nevada has been studied by Das et al. (2011). Their models predict larger-than-historical floods for both the northern Sierra Nevada and the southern Sierra Nevada, with increases in flood magnitude projected for the period 2051–2099. These projections highlight the importance of planning for increased flood events and considering risk to local communities, to the recreation and tourism industry, and to water quality and availability downstream.

Research and modeling efforts have resulted in some tangible management implications. For example, Mehta et al. (2011) recommended that climate change-induced hydrological change be included as a foreseeable future condition in planning and in Federal Energy Regulatory Commission relicensing.¹⁰ Peterson et al.

¹⁰ This is regarding hydropower and dams. See <http://www.ferc.gov/about/ferc-does.asp> to learn what the Federal Energy Regulatory Commission roles are.

(2011) produced a guidebook on responding to climate change, and it may be useful in larger scale planning and adaptation. It is evident that climate change is incredibly complex, and requires working at a long time scale, large geographic scale, and across agency and institutional boundaries, and a willingness to accept a degree of uncertainty (Barbour and Kueppers 2012).

Wildland Fire

Public perceptions of wildland fire and risk—

Sociocultural and economic aspects of wildland fire management have been an area of intense study for the last decade, stimulated by funding from the National Fire Plan that increased support for related work. A number of comprehensive reviews are available on this topic (see the appendix for additional references). Some of this research emerged from the risk management field, and may be instrumental in understanding management of other risks and threats. However, caution should be exercised in this approach, as not all risks are viewed equally or are associated with the same sociocultural concerns.

A recent national assessment of wildfire risk to human and ecological values identified California as having among the highest expected losses, in part owing to the density of built structures in fire-prone areas (Thompson et al. 2011). People living in high fire risk zones tend to underestimate that risk (Kumagai et al. 2004). The risk of wildland fires receives low levels of consideration when prospective residents are considering purchasing a home in a fire-prone area; however, once residency is established homeowners give some consideration to risk (Vogt 2008). In many cases, residents in fire-prone communities have been found to take a number of risk-reduction actions (Absher and Vaske 2007, McCaffrey 2006, Vogt 2008). Perceived risk is not the only influence in defensible space actions; for example, individuals need to be confident in their ability to perform the action (Martin et al. 2008), and they need to feel that the action will be effective in reducing risk (Martin et al. 2008).

Collaborative approaches to fire management and risk reduction tend to contribute to effective risk management. Successful approaches require addressing knowledge gaps between experts and laypersons to increase effectiveness of engagement efforts (Simons and Arvai 2004). A benefit of the collaborative process is the opportunity for the risk manager to learn stakeholder perspectives on the places of concern or the techniques involved, as well as to address their own gaps in knowledge (Slovic 2000). Fostering mutual learning rather than relying on instruction is characteristic of this mode of addressing management. However, building public understanding and agreement requires a long-term commitment (Olsen and

Shindler 2010), and involves fostering and building trust and confidence among participants and the managing agencies (see Rivers et al. 2008, Winter et al. 2007).

Impacts of wildland fire—

The complexities of fire management have increased in the Sierra Nevada mountains and foothills, in part owing to increased development in the wildland-urban interface (Hammer et al. 2007). The importance of participating in local and regional land use planning efforts and discussions of fire risk has increased, as has the need for agencies to collaborate across boundaries, and with citizens and community groups (examples of some of these approaches appear in chapter 9.6).

Fire can evoke significant emotional distress and panic during a fire event (Simons and Arvai 2004), and lingering psychological impacts associated with a fire event and fire risk were shown to affect residents near fire-prone forest lands (Cvetkovich and Winter 2008). Fires that directly affect forest communities can alter community structure; however, engaging community members in collaborative approaches to recovery may be effective in restoring community and healing impacts of the event (Burns et al. 2008). Smoke is one specific area of concern to individual health from wildfires. Fowler (2003) reviewed human health impacts of forest fires. She pointed to the importance of evaluating forest fires from the perspective of gains (improved social, cultural, economic, and political systems) as well as risks (e.g., through short and longer term impacts on public health). Chapter 4.2, “Fire and Tribal Cultural Resources,” considers how fires, including wildfires, can provide benefits by sustaining tribally valued resources and associated lifeways, although the specific impacts of wildfires of different size and severity to such resources need further examination. Specific impacts of concern to vulnerable populations overlap those for air quality in general and include impaired visibility from smoke as well as health effects on young children, the elderly, and individuals with pre-existing conditions (Fowler 2003). An additional health concern is the occupational exposure for firefighters (Fowler 2003). The literature on impacts to infrastructure from impaired air quality may be helpful in pointing to additional areas of consideration, for example, the damage caused to exteriors of buildings from pollutants (see Winter 1999). Sandburg et al. (2002) examined the effects of fire on air quality and provide some analyses of impacts from fire and smoke, pointing to the effects of damage to infrastructure and reduced highway safety. McCool et al. (2007) provide an extensive review of wildland fire impacts on communities at the individual, family, neighborhood, social group, and community scales, demonstrating the complexities of scale when applying social science to management of fire.

Large wildfires may impact soils, in turn affecting human health. Chapter 5.1, “Soils,” notes the potential for wildfires to mobilize heavy metals, which may also have accumulated in the Sierra Nevada owing to atmospheric deposition (see chapter 8.1). Studies examining heavy metal concentrations demonstrate the transfer into food supplies, particularly in areas where residents engage in outdoor gardening, or where residents and visitors collect edible forest plants and fungi (see, for example, Alm et al. 2008). Fire is only one of many ways that heavy metals may be introduced into the ecosystem and subsequently into the food supply (Sharma and Agrawal 2005), but it remains an important area of concern in the Sierra Nevada and other fire-prone regions.¹¹

Impacts on recreation and tourism—Fire has impacts on recreation and tourism that in turn may have economic impacts. For example, a fire in July of 2000 was associated with decreased economic activity and visitor expenditures when fire crews filled up local lodging and smoke lingered in the Kern River Valley for several weeks, impairing local scenic views and air quality (Colby and Smith-Incer 2005). Studies suggest there are a number of economic costs of forest fires that are not typically considered (Dunn et al. 2005, Yoder and Blatner 2004), and when they are accounted for, investments to reduce fire risk and increase treatments may seem more financially prudent (Yoder and Blatner 2004).

Longer term effects of wildfires on recreation and tourism have also been examined. Wilderness visitation is affected by fire succession according to Englin et al. (2008), who reported that large wildfires are followed by an increase in the number of trips to an area, but over the longer term (40 to 50 years out), large areas burned by wildfires experience decreased demand. Further studies are needed to understand the dynamics underlying these patterns, but in the interim, these fire-caused shifts in demand may be important for planning purposes.

Loomis et al. (2001) reported variable effects of forest fires on recreation and tourism associated with the intensity of the fire and recreation use activity. Effects can vary, depending on impacts to the landscape and the activity in question; for example, hikers find obstructions less of an issue along a trail than do mountain bikers. Similar to Englin et al. (2008), Loomis et al. (2001) reported a decrease of use in some areas over time; however, this effect was for hikers. Recovery of an area was associated with increased mountain biking activity. Loomis et al. (2001) suggested practicing agency communications that allow user groups to understand fire impacts and make informed choices about where to go based on recency and

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¹¹ Mining is another likely source that has introduced heavy metals into the ecosystems in the synthesis area, addressed in chapter 6.1, “Watershed and Stream Ecosystems.”



Figure 2—Burned stump of giant sequoia tree, Sequoia National Park.

type of fire (see fig. 2). This approach might help mitigate economic losses associated with reduced tourism after a fire.

Other studies suggest minimal impact of fires on the overall experience of recreationists (Winter and Knap 2008) and tourists (Thapa et al. 2008). However, high fire danger conditions (Thapa et al. 2008), smoke from a nearby fire (Winter and Knap 2008), and health problems from smoke and ash (Thapa et al. 2008) are viewed as bothersome, and in some cases, these issues are of sufficient concern to inspire changes in travel plans. Fire management activities may need to involve an evaluation of the potential for such impacts, and suggest actions to forestall disruptions (see Bricker et al. 2008).

Social and institutional factors regarding smoke emission—To dramatically reduce the legacy of fire suppression and associated fuel loading and restore the role of fire would require a sharp increase in the level of burning and emissions, which in turn would require increased political support (Stephens et al. 2007). Public land management agencies have an incentive to respond to short-term, local complaints about smoke while discounting hypothetical impacts from future wildfires. The fact

that wildfires are often excluded from the regulatory constraints that apply to prescribed burns further diminishes the incentive to avoid wildfires through prescribed burning. Efforts to increase burning raise equity concerns by asking current residents and tourism-related businesses to bear a burden partially created by prior generations in order to mitigate impacts to future populations. Education, notification, and other outreach measures may help to diminish residents' concerns, but fundamentally, prescribed burning requires sacrifice on the part of current local residents for the sake of a greater public good. On the other hand, it may also be important to emphasize the potential for planned burns to promote near-term benefits, by stimulating production of desirable habitat conditions, and addressing social and cultural benefits, as discussed in chapter 4.2 (see also Venn and Calkin 2009).

Invasive Species

The impact of invasive species can be extensive, resulting in economic losses, permanent ecological changes (such as the loss of native species), and effects on public health and well-being (Andersen et al. 2004). Emphasis on the impacts of invasive species, including pathogens or diseases, tends to focus on only a portion of ecosystem services (Charles and Dukes 2007). However, with an increasing need to clarify impacts of invasives to the public at large, and to weigh management options in terms of costs and benefits of management and prevention, a broader approach is suggested. For example, the economic impact of weeds on wildlife-related recreation in the Sierra Nevada was recently estimated between \$6 and \$12 million per year (Eiswerth et al. 2005). This broader approach would incorporate impacts on "regulating ecosystem services," including ecosystem processes affecting air quality, climate, water, disease, and erosion. Charles and Dukes (2007) demonstrated the importance, for example, of considering the role of invasives in increasing fire risk, thus increasing concerns over degraded air quality and associated effects. Impacts to fire regimes of the Sierra Nevada can also occur from invasives (Brooks et al. 2004), thus affecting values or conditions of ecosystem goods and services.

Emergent findings also encourage consideration of invasive impacts on cultural ecosystem services, including aesthetic value and tribal uses and access (Pfeiffer and Ortiz 2007). Finally, Charles and Dukes (2007) pointed out the need to consider impacts on supporting ecosystem services, such as longer term ecosystem dynamics (e.g., photosynthesis or soil nutrient cycling). The authors noted, however, the relatively low availability of completed work outlining impacts of invasives on regulating and supporting ecosystem services; this represents an important gap in the information necessary to fully assess and select appropriate management investments into the future.

Finnoff et al. (2005) pointed out the importance of examining a bioeconomic feedback loop in invasive species management, considering the expected benefits of adapting or controlling invasives versus lost benefits expected through inaction. An example for native versus exotic fish species demonstrates the complexity of recreational values held by the public. Some stakeholders, such as fishermen using national forests, may value more “pristine” lake, stream, or river fish communities compared with others who want the opportunity to “catch a fish” regardless of the species’ origin or ecological function (Moyle et al. 2003). As previously discussed in chapter 9.1, a sustainable approach to recreation and tourism considers multiple dimensions in order to inform management decisions. Although stocked fish have been linked to detrimental effects on native fish and amphibians (see chapter 6.4, “Lakes: Recent Research and Restoration Strategies,” recreational fishing on public lands has also been supported by stocking of nonnative fish (Deisenroth et al. 2012). Benefits to the national economy are derived from anglers, for example, through retail sales of fishing equipment and tourism, and some communities may benefit from more direct support, as fishing opportunities may bring in recreationists and tourists who help support the local economy during their visit. The annual economic contribution to the Western United States is estimated at \$2 billion (Deisenroth et al. 2012). However, the economic losses from exotic fish have been estimated at more than \$1 billion annually (Pimental et al. 2000). As presented in the previous discussion of sustainable recreation management, these choices are complex and cannot be distilled to assessments of ecosystem services lost or protected when considering a singular action or species (DeLeo and Levin 1997). Evaluations of the economic impacts of management actions, such as reduced stocking of nonnative fishes, should consider local contexts, because changes in angler demand are sensitive to the proportion of angling in streams, banks of lakes, and boats, as well as possibly to angler motivations (Loomis and Fix 1998). Both remediation and prevention of invasives require an assessment of priorities and the weighing of perceived effectiveness (Randall 2010). It further requires a deliberative process to address the multiple and sometimes conflicting values that would be outlined in a formal decision analysis (see Maguire 2004).

The management of invasive species is especially difficult in areas with high land use diversity and increasing division of lands among multiple owners or agencies (Epanchin-Niell et al. 2010). Collective action across agency boundaries is necessary to effectively address control of invasives and promote socioecological resilience.

Decisionmaking Science and Effects on Risk Management

Sustainability assessment tools and the indicators selected within them often reflect the values of the evaluators who select the tools and indicators (Gasparatos 2010). Chapter 9.1 considers sustainability surrounding recreation and tourism, including efforts to encourage global use of metrics for sustainability. Decisions regarding which values are important will influence how ecological, social, economic, cultural, and institutional sustainability are conceptualized and measured, as well as thresholds for making changes in management direction. These indicators and thresholds are an important consideration in an adaptive management framework, as described in chapter 1.3, “Synopsis of Emergent Approaches.” To be meaningful and promote sustainability, selected indicators and feedback loops should consider impacts to affected stakeholders. A mix of indicators and values may be needed to represent the interests of diverse stakeholders.

All considerations are not weighed equally in decisions regarding risk. For example, ample evidence suggests that gains tend to be discounted more than losses in environmental decisions (Hardisty and Weber 2009). In addition, short-term losses gather more attention than longer term ones, in part because of the belief that some change intervention will be possible in the future to mitigate longer term losses (Wilson et al. 2011). This has been referred to as risk-averse decisionmaking (Maguire and Albright 2005). The focus on addressing and preventing short-term losses and risks further impedes the ability to address longer-term sustainability and resilience. Maguire and Albright (2005) offer solutions to risk aversion in decisionmaking, including increased use of structured decision processes to overcome mental shortcuts, a shift in reward systems to encourage adaptive management, and increased locally focused collaborations that improve an understanding of management goals and practices. An additional benefit is the improved accessibility and usability of local knowledge, also essential to improved decisionmaking processes and outcomes (MacGregor and González-Cabán 2008).

Furthermore, institutional, political, and social constraints impinge on public land managers’ decisions and should be accounted for in modeling of socioecological resilience, supporting tools, and suggested applications (Dellasala et al. 2004, Horan et al. 2011, Quinn-Davidson and Varner 2012). For example, Williamson (2007) reported that Forest Service district rangers cited a concern over lack of agency support (through limited budgets and the risk of personal liability) in decisions surrounding wildland fire use. Air quality regulations were also cited as an impediment. Areas of public concern, including smoke, risks to threatened and endangered species habitat, and resource damage were also cited as influences on decisions about fire use. Thus, recommended approaches need to incorporate

Decisions regarding which values are important will influence how ecological, social, economic, cultural, and institutional sustainability are conceptualized and measured, as well as thresholds for making changes in management direction.

contextual factors, not only in the recommendations offered for management, but also in the selected indicators for monitoring. Contextual factors need to be realistically examined in discussions of management of threats, and they need to include a feedback loop to account for changes over time.

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