

Annotated Bibliography

Social Vulnerability and Wildfire in the Wildland-Urban Interface

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About the Northwest Fire Science Consortium:

The Northwest Fire Science Consortium works to accelerate the awareness, understanding, and adoption of wildland fire science in Washington and Oregon (excluding the SE corner). It connects managers, practitioners, scientists, and local communities and collaboratives working on fire issues on forest and range lands. The Northwest Fire Science Consortium is one of the 15 regional exchanges established by the Joint Fire Science Program's Fire Science Exchange Network to bring fire science users together to address regional fire management needs and challenges. Each regional exchange provides current and regionally-relevant wildland fire science information to users in the region. For more information: <http://www.nwfire-science.org/>.

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1999

Morrow, Betty. "Identifying and mapping community vulnerability." *Disasters* 23, no. 1 (1999): 1-18.

Main finding: Disaster vulnerability is compounded for certain marginalized groups and can be mapped by identifying certain demographic patterns such as ethnic, racial, and economic makeup. These populations are found to have limited access to resources to cope with disaster impacts. Women, as well, have unique needs related to disaster vulnerability. Land managers have the capability to mediate these circumstances that contribute to vulnerability through research and informed policymaking.

This article applies international discussions of disaster vulnerability to American demographic trends by using a case study analysis of Hurricane Andrew to illustrate social and economic factors influencing disaster risk. In particular, this research investigates how poor, elderly, women-headed, and migrant households hold positions of greater risk to disaster hazards. In this literature-driven case study, the author reiterates critical arguments that racial and economic factors compound risk because of existing capital-driven, patriarchal political systems which put disadvantaged people in precarious living situations. While poverty contributes directly to vulnerability, that risk increases when poverty intersects with other marginalizing characteristics among minority or disenfranchised communities. Moreover, women face unique obstacles related to disaster vulnerability that are associated with economic conditions in disaster-prone areas, social autonomy, and cultural expectations of women as caregivers—thus, they should be included in risk mitigation planning as a valuable resource for disaster management. More broadly, identifying concentrations of vulnerable groups can positively inform management decisions. The author contends that land managers can mediate this compounded risk by identifying and mapping vulnerable communities or households, examining their unique situations in regards to vulnerability, and proactively compensating for vulnerability through informed policy. The author sees this process as inherently political, with resilience originating from a strong working relationship between communities and policy leaders that is not strictly determined by social or economic circumstances that are seen as leading to vulnerability. Addressing disaster vulnerability requires actively involving communities and groups throughout the planning and response process and working collaboratively to create change at the roots of vulnerability. Disenfranchised or marginalized groups can productively contribute to addressing vulnerability, evidenced by grassroots organizations. In conclusion, the author contends that effective hazard mitigation begins at the local level and requires collaboration between institutions and the vulnerable populations they set out to protect.

2003

Cutter, Susan L., Bryan J. Boruff, and W. Lynn Shirley. "Social vulnerability to environmental hazards." *Social Science Quarterly* 84, no. 2 (2003): 242-261.

Main finding: While there is no consensus in the social science community about the correlatives of social vulnerability, the hazards-of-place model of vulnerability indicates that social vulnerability is a multidimensional, dynamic set of circumstances that can be measured. Therefore, indexing specific community characteristics allows researchers and officials to identify at-risk communities, enable them to respond to environmental hazards, and help them recover from disasters.

The authors use socioeconomic and demographic data from 1990 at the county level to construct a Social Vulnerability Index for the United States, citing the lack of functional systems to track the intersection of environmental risk and social disparity. In constructing this index, they considered three main methods of measuring vulnerability in particular environments, which they call "hazards-of-place": conditions that make people vulnerable to extreme natural events, such as building density and access to resources, exposure to natural hazards, and social conditions influencing vulnerability and limiting or supporting community resilience to hazards. Researchers used the hazards-of-place model to examine these intersecting components of social vulnerability to track how vulnerability is mediated or amplified by geographic location and social conditions of place, including experience with hazards and subsequent resilience. The authors use a factor analytic approach to reduce 42 variables into 11 composite factors influencing social vulnerability. These include: (1) personal wealth; (2) age; (3) density of the built environment; (4) single-sector economic dependence; (5) housing stock and tenancy; (6) race—African American; (7) ethnicity—Hispanic; (8) ethnicity—Native American; (9) race—Asian; (10) occupation; and (11) infrastructure dependence. There were some distinct spatial patterns identified with the most vulnerable regions being metropolitan counties clustered in the eastern United States, south Texas, and the Mississippi area. The factors that increased a county's vulnerability often differed, reflecting the interactive nature of social vulnerability—some combinations of factors increased vulnerability, while other combinations increased resilience. Researchers concluded that employing the hazards-of-place model and examining social vulnerability as a risk factor can assist land managers in enabling communities to respond to and recover from environmental hazards. Further research can track temporal patterns of social vulnerability as identified through the Social Vulnerability Index, which can inform projections of vulnerability to hazards and facilitate preemptive risk mitigation.

2005

Collins, Timothy W. "Households, forests, and fire hazard vulnerability in the American west: A case study of a California community." *Global Environmental Change B: Environmental Hazards* 6, no. 1 (2005): 23-37.

Main finding: WUI hazard vulnerability requires examination of complex interactions of geographic, social, and policy issues to measure a community's capacity to respond to or preempt wildfire. Attention to political economic constraints can contribute to such an examination to help communities and agencies mediate fire risk.

This article examines WUI fire hazard vulnerability through a case study of the Forest Ranch community in California to assess the effectiveness of current management interventions. Combining biophysical and socio-political perspectives, the author considers four determinants of fire hazard vulnerability: (1) risk perception, (2) amenity value conflicts, (3) institutional incentive structures, and (4) political economic con-

straints. The author thus argues that these determinants, particularly amenity value conflicts and political economic constraints, combine to influence social vulnerability in WUI regions. In the author's formulation of a political economic framework, which offsets existing biophysical frameworks, vulnerability reflects an individual's capacity to anticipate, cope with, and recover from environmental hazards. The author notes that current research metrics on WUI hazards fails to distinguish the vulnerability levels of indigenous or working-class WUI residents with wealthy amenity migrants by aggregating income demographics in ways that conceal households at disproportionate risk from results. Approaching impacts of marginalization and social shock from an environmental justice perspective, the political economic framework suggests that vulnerability is higher in low-income households with limited access to adaptive resources. Although wealthier households seem more active in reducing fire risk, residents are typically less likely to implement preemptive measures to prevent wildfire if they believe firefighters have the capability to protect structures. Study participants were vulnerable because they (1) assigned amenity values to environmental characteristics that contribute to biophysical risk, such as densely vegetated forest property; (2) considered fire suppression as an adequate replacement for mitigation; (3) lacked access to adequate roads and water sources; (4) lacked economic resources to invest in fire safety; and (5) as non-property owners were legally prevented from making adjustments. In conclusion, the author notes that the coexistence of high- and low-income populations problematizes singular representational models and concepts of hazard vulnerability—management practices should therefore involve generating contextualized, comprehensive management plans. Recognizing this challenge to hazard vulnerability assessment and management will allow communities and agencies to productively mediate risk by examining vulnerability through a combination of biophysical, socioeconomic, and political lenses.

Flint, Courtney G. and A.E. Luloff. "Natural resource-based communities, risk, and disaster: An intersection of theories." *Society & Natural Resources* 18, no. 5 (2005): 399-412.

Main finding: Research into vulnerability and community adaptability should consider both biophysical risk and social constructions of risk; this interactional theory of community resilience can lead to greater community agency.

This article draws attention to the shortcomings of research regarding natural resource-based communities' vulnerability to disasters, arguing that such research does not adequately consider community interactions and responsiveness to risk. The authors propose an alternative framework to existing models of risk and vulnerability that they call an interactional theory of community, which connects local agency and social perceptions of risk to physical and social risks and disaster vulnerability. This framework pushes back against research that presents natural resource-based communities as helpless in the face of risk and that maintain a status quo regarding community impact, practices which increase marginalization and therefore, increase vulnerability. The authors argue that there is a need for theory that combines the objective and subjective aspects of risk and grounds inquiry within communities, which are the places and circumstances where risk is experienced. They argue that how communities respond to risk depends on three factors: (1) combined biophysical and socioeconomic vulnerability, or the "risk context"; (2) social constructions of risk on a community level; and (3) interactive capacity at the local level to address problems collectively. The researchers assert that the field of risk and vulnerability research needs to be attentive to the dynamic overlap of social and environmental factors, that social constructions and technically assessed characteristics of a biophysical environment are related, and that mixed methods are necessary to understand and address vulnerability while building community resilience.

2006

Eakin, Hallie, and Amy L. Luers. "Assessing the vulnerability of social-environmental systems." *Annual Review of Environment and Resources* 31 (2006): 365-394.

Main finding: The range of methods and arguments regarding social-environmental vulnerability is key to collaborative efforts to minimize risk exposure. Future models to assess vulnerability should consider the outcomes and methods of prior research in order to productively integrate paradigms and approaches that may not be fully compatible.

This review article traces the conceptual progression of social-environmental vulnerability research and highlights emerging insights into the field. The authors contend that diverse perspectives on vulnerability facilitate comprehensive studies of the topic and are necessary for addressing the various elements and configurations of vulnerability. Even though researchers note a general sense of confusion in defining and studying vulnerability, the various theories and models can be seen as complementary instead of fragmented, indicating future synergy that could lead to even greater relevance and usefulness for policy makers. The authors consider approaches to social-environmental vulnerability including biohazard risk, vulnerability mediation, environmental justice, and equity in their overview of frameworks for assessing vulnerability. In collecting various approaches to social-environmental vulnerability, they attempt to synthesize complementary efforts to minimize risk, even when those efforts are backed by contradictory political or ideological positions. Considering the diverse range of perspectives on social-economic vulnerability allows researchers to create metrics and models that guide holistic examinations of specific regional contexts. Such research considers the various methods available for researching social-environmental vulnerability as well as the factors that drive inequity and risk exposure. The authors conclude that concepts of vulnerability come out of cultural, political-economic, and geographic research models, and that embracing the interdisciplinary nature of vulnerability studies will enable researchers to achieve the ethical ambition that comes with studying risk and equity among marginalized populations.

2008

Cutter, Susan L., Lindsey Barnes, Melissa Berry, Christopher Burton, Elijah Evans, Eric Tate, and Jennifer Webb. "A place-based model for understanding community resilience to natural disasters." *Global Environmental Change* 18, no. 4 (2008): 598-606.

Main finding: Though still in its developmental phase, the DROP model is designed to consider antecedent conditions, hazard event characterizations, cumulative effect, and degree of recovery as crucial to measuring inherent resilience. Research through the DROP model, therefore, can inform economic, social, and environmental policy to support regional resilience to natural disasters.

This research brings together existing work on standards and measurements of social vulnerability and resilience, offering a new framework to understand the dynamic factors affecting community capacities to recover from disasters. The authors see their work as responding to a lack of concerted effort by the U.S. government to address vulnerability proactively and a lack of critical consensus on how to measure vulnerability and resilience concurrently. The authors describe a set of variables for measuring disaster resilience and provide a conceptual framework supported by existing literature, political ecology, hazards, climate change, and ecosystems. In designing their model for assessing vulnerability, which they term the disaster resilience of place (DROP) model, the researchers identified common areas of concern in existing models and frameworks: (1) socio-ecological vulnerability, (2) place-based studies, (3) the equity or human rights dimension of vulnerability, and (4) identification of hazard zones through vulnerability

assessment. The DROP model is intended to facilitate comparative assessments of disaster resilience, with researchers considering existing models and their limitations. The DROP model offers a theoretically grounded, quantifiable model of addressing natural hazards faced by populations of specific places. It considers resilience a dynamic process that involves preexisting conditions, the severity of a disaster, the timing of hazard events, and external factors inhibiting or facilitating access to resources. The authors conclude that comprehensive frameworks, like the DROP model, allow researchers and policy makers to better understand and measure natural hazard resilience at the community level. However, such models are limited in their capacity as static descriptions. Therefore, the next steps involve operationalizing the model, developing a set of common indicators, and testing the model in real-world applications, thus requiring ongoing research on resilience metrics.

Collins, Timothy. “The political ecology of hazard vulnerability: marginalization, facilitation and the production of differential risk to urban wildfires in Arizona’s White Mountains.” *Journal of Political Ecology* 15, no. 1 (2008): 21-43.

Main finding: Wildfire risk is impacted by local economic dynamics, further marginalizing and putting poor or working class locals at risk. In Arizona’s White Mountain region and on the White Mountain Apache reservation, ongoing shifts in the local economy from resource extraction to amenity facilitation resulted in marginalization of residents and increased fire risk on a broad scale.

This article examines wildfire vulnerability through a political ecology framework, considering the impact of shifting economic conditions in Arizona’s White Mountains, as the area has transitioned away from a post-settlement natural resource economy towards a mixed labor and amenity economy. The author considers the impacts of political ecology on fire resilience for working class populations in the White Mountains region, including on and off the White Mountain Apache reservation, considering historical influences of colonialism and extensive resource development. In doing so, the author extends political ecology to include marginalization and facilitation to examine complex human-environment relationships in particular places. The author combines this political analysis with quantitative and qualitative research of local involvement within the White Mountain’s amenity economy and fire preparedness, using this juxtaposition to understand how marginalization impacts local residents’ vulnerability to wildfire. The author examines the factors influencing hazard vulnerability in the White Mountains as differentiated based upon marginalization and facilitation. This distinction occurs in terms of residents occupying environments defined as either livelihood or lifestyle landscapes. To this end, the author finds that economic transformation in the White Mountains has marginalized working class locals by catering to wealthy amenity seekers from metropolitan areas, resulting in higher wildfire risk for locals. The author concludes that facilitation as a concept of political ecology lends insight into the social patterns of land management in regions where privileged and marginalized populations coexist, often holding opposing attitudes about the environment and best practices for managing lands. These concepts of marginalization and facilitation, the author contends, offer a means of thinking about political ecology of risk, particularly wildfire.

Cutter, Susan L. and Christina Finch. “Temporal and spatial changes in social vulnerability to natural hazards.” *Proceedings of the National Academy of Sciences* 105, no. 7 (2008): 2301-2306.

Main finding: Rather than measuring social vulnerability as a static set of conditions, tracking temporal and spatial changes in conditions that contribute to social vulnerability can provide a more comprehensive representation of vulnerability over time. By addressing social vulnerability as a dynamic process, communities can increase resilience based upon their unique historical contexts.

This paper examines the historical variability in natural-hazard vulnerability in the United States from the 1960s to the 2000s. The research is intended to fill gaps between risk hazards and human-environmental research communities, attempting to offset the lack of empirical literature on vulnerability in social systems. The authors rely on existing literature to determine that factors influencing vulnerability include race, ethnicity, socioeconomic class, gender, age, migration, and housing type. Based on this determination, the authors create an index to measure vulnerability in specific geospatial contexts. They use the resulting Social Vulnerability Index (SoVI) to compare social vulnerability to natural hazards across counties based on their socioeconomic and demographic profiles. While spatial patterning of social vulnerability was initially concentrated in particular geographic regions—the deep south (race, gender, socioeconomic status), southwest (Native American lands), and Florida (elderly populations)—the mapping of county SoVI scores over five decades shows a more dispersed pattern of social vulnerability over time. In all decades under study, Cutter et al. found that the most dominant component underlying social vulnerability was socioeconomic status. The remaining dimensions of social vulnerability, including the level of development of the built environment, age, race/ethnicity, and gender, accounted for almost half of the variability among U.S. counties in natural-hazard vulnerability. Density (urban), race/ethnicity, and socioeconomic status correlated consistently with increased social vulnerability during all time periods. The authors conclude that because patterns of social vulnerability tend to mirror the geography of inequality and poverty, the SoVI can help identify which places may require specialized attention within the context of natural hazards. The authors also discuss the value of the SoVI in a larger context of social policy as it may be applied in the determination of counties most in need of socially-based services that could improve the quality of life of residents as well as their capacity to respond and recover from disaster events. They contend that SoVI projections should be addressed years in advance to strengthen communities' resilience to hazards.

2009

Collins, Timothy W. and Bob Bolin. "Situating hazard vulnerability: People's negotiations with wildfire environments in the U.S. southwest." *Environmental Management* 44, no. 3 (2009): 441-455.

Main finding: Residents in forested regions hold differing or oppositional values about the environments in which they live, which makes understanding wildfire hazard vulnerability a complex issue. By considering both social vulnerability and biophysical hazard risk factors in concert, however, managers can productively initiate risk mediation practices among both long-term and amenity migrant residents.

This research uses a multimethod study to examine the links between biophysical hazards, social vulnerability, and wildfire risk, using a case study of Arizona's White Mountains, where the prevalent environmental hazard is wildfire. Both long-term residents and newcomers are confronted by fire hazard, facing challenges related to collective risk mediation. The authors connect their findings to existing literature on wildfire hazard vulnerability research to determine that social vulnerability as a factor in wildfire risk is amplified by amenity migration—the influx of typically wealthy residents into densely forested regions—which complicates access to fire mitigation resources for low-income residents, whose access to those resources may already be limited. The authors contend that social structures, inequalities, and power relations result in imbalanced attitudes and access to fire prevention resources, such as insurance and fire management services and equipment, and that these imbalances diminish the culture of prevention. The authors compare attitudes toward fuel reduction, cost issues related to thinning or reducing flammable fuels from properties, and environmental values between long-term residents and amenity migrants. In many cases, wealthy amenity migrants have greater access to resources such as insurance and fire management services and therefore, rely on these resources for protection rather than reducing fuels, a position related to their desire for densely forested properties. They found that long-term residents,

though often financially limited as to what forms of risk reduction they can undertake, are more likely to reside in the White Mountains, regardless of fire resource access, due to a strong sense of belonging. Amenity migrants, however, prefer to keep their properties densely forested and would not reside in the White Mountains if they had no access to firefighting services or fire insurance. The researchers conclude that these equity issues mean environmental managers should seek a comprehensive understanding of the factors that influence vulnerability and facilitate stakeholder collaboration through policies designed to develop safer and more sustainable forest living environments. These factors include improving understanding of stakeholder's environmental preferences, recognizing implicit incentives for undergoing risk management programs, and providing support to marginalized households to help address social vulnerability and increase resilience throughout the region.

2011

Gaither, Cassandra J., Neelam C. Poudyal, Scott Goodrick, J.M. Bowker, Sparkle Malone, and Jianbang Gan. "Wildland fire risk and social vulnerability in the southeastern United States: An exploratory spatial data analysis approach." *Forest Policy and Economics* 13, no. 1 (2011): 24-36.

Main finding: "Hot spots" in the southeastern United States are located farther from fire mitigation programs than comparable communities of high fire risk and low social vulnerability. Social vulnerability, therefore, occurs in measurable patterns that can be used to identify risk in fire-prone regions.

This research investigates patterns of social vulnerability in the southeastern United States. This region is one of the more wildland fire-prone in the country and contains some of the most socially vulnerable rural communities. The authors examine distances between fire mitigation programs and hot spots (defined as areas of high risk of wildfire coupled with high social vulnerability), as well as areas of high fire risk and low social vulnerability. They hypothesize that residents in hot spots are less likely to undertake mitigation programs than those in areas of high risk and low vulnerability. Results show greater distance between hot spots and mitigation programs than between high risk/low vulnerability areas and similar mitigation programs. Their findings support existing research which suggests that social vulnerability compounds problems for low income or minority communities when it comes to accessing fire adaptability resources and recovering from fire events. As well, socially vulnerable populations appear less likely to participate in fire prevention activities due to sociocultural practices and/or lack of financial resources to undertake fuel reduction projects. This research contributes to the ongoing study of factors impacting social vulnerability to disasters, including wildfire, and the forms of inquiry necessary on the part of land managers to identify the social dynamics contributing to wildfire vulnerability in fire-prone regions of the United States. The authors conclude that these socio-cultural landownership trends can inform land management practices and that this work can be useful for wildland fire studies in the southern U.S. by offering practical insights for fire managers addressing natural as well as social patterns contributing to risk.

2012

Bihari, Menka and Robert Ryan. "Influence of social capital on community preparedness for wildfires." *Landscape and Urban Planning* 106, no. 3 (2012): 253-261.

Main finding: Social capital is enhanced by strong place attachment, strong community involvement, and knowledge-sharing, which in turn increases preparedness for fires in WUI communities. By assessing and developing social capital, land managers and planners can raise community awareness about wildfire risk and reduce fire danger through preparedness.

This research examines how place attachment and prior wildfire experience shapes community social capital, which in turn shapes wildfire preparation and awareness. The authors review literature that suggests that social capital derives from community cohesion, which facilitates coordinated efforts to reduce wildfire risk factors and promote wildfire awareness to reduce fire danger in WUI communities overall. The research involved a survey of six fire-prone regions in western (Rocky Mountain region), southwestern, southeastern, and eastern states regarding residents' attitudes about fire preparedness, prior experience with wildfire, and their sense of community cohesion. Participants were selected based on location, wildfire history, WUI proximity, engagement between the community and agencies, assistance programs funded by the National Fire Plan, and education and outreach programs. The survey process yielded that positive relationships within communities and place attachment result in wider participation in local efforts to mitigate wildfire risk through local associations and activities. The authors found that past experience with wildfire and strong place attachment positively impacts social capital and, as a result, informs fire preparation efforts. Moreover, they concluded that collaborative relationships between long-term residents and newcomers will contribute to fire mitigation activities through sharing knowledge—both experiential and informational—thus building social capital alongside wildfire preparedness. The authors contend that managers and land-use planners can use results from this study to foster community awareness and preparation efforts, which will enhance social capital while reducing fire danger.

Paveglio, Travis, Matthew Carroll, Pamela Jakes, and Tony Prato. “Exploring the social characteristics of adaptive capacity for wildfire: Insights from Flathead County, Montana.” *Human Ecology Review* 19, no. 2 (2012): 110-124.

Main finding: Adaptive capacity varies across communities and is impacted by community identity, networks, and the wood products industry within the area. Specific characteristics like these should be documented by managers and community wildfire response teams to increase wildfire adaptability and facilitate productive changes in wildfire response capacity.

This research examines aspects of local social context contributing to adaptive capacity for wildfire in Flathead County, Montana communities. The research aligns with existing scholarly conclusions, finding that in order for communities to reduce vulnerability, they must first have the will, resources, and motivation to reduce potential impacts of wildfire through preventative action. Adaptive capacity, in this sense, refers to the combination of social factors that facilitate or limit community and individual agency to reduce vulnerability and increase resilience. The researchers consulted fire professionals, emergency managers, and community members through individual interviews and focus groups. They employed a framework of adaptive capacity that considers: (1) resident knowledge of the ecosystem in their area in regard to wildfire; (2) access to scientific or technical information to facilitate adaptability; (3) demographics and access to resources; and (4) community networks to foster collective action. The adaptive capacity framework relies on an interactional approach to achieve a holistic view of local context through multiple actors. The authors conclude that understanding adaptive capacity for wildfire on a community level requires paying attention to social characteristics related to wildfire management on the professional, residential, and management levels specific to a particular region or community. The research shows that community identity is a necessary prerequisite for collective adaptive action to mediate wildfire risk. Using and expanding the adaptive capacity framework for wildfire can facilitate organized analysis of the complex social conditions affecting wildfire adaptability. Further work in this field will continue to examine local factors affecting adaptability, devising critical frameworks that account for these factors, and projecting likely outcomes of predictable situations and their characteristics.

Poudyal, Neelam C., Cassandra Johnson-Gaither, Scott Goodrick, J. M. Bowker, and Jianbang Gan. “Locating spatial variation in the association between wildland fire risk and social vulnerability across six southern states.” *Environmental Management* 49, no. 3 (2012): 623-635.

Main finding: South Carolina and Florida have significant concentrations of socially vulnerable populations residing in areas of high fire risk. However, hazard vulnerability in the South is driven not by amenity migration, but by poor land management related to WUI development. Using mapping methods to locate social vulnerability can facilitate productive land management to mitigate fire risk.

This research examines the association between social vulnerability and wildland fire risk in the southern United States. The authors argue that increased hazard vulnerability is not driven by wealthy amenity migrants, but rather by poor development and land management practices, and that working class, poor, or socially vulnerable populations endure greater losses from wildfire due to social patterns affecting access to disaster resources and mitigation programs. The research uses geographically weighted regression to assess hazard vulnerability through the association of rural, forested, and urban lands in Alabama, Arkansas, Florida, Georgia, Mississippi, and South Carolina. To do this, the authors employ ordinary least squares regression and geographically weighted regression models to map vulnerability by census block. Using this method, the authors identify “hot spots,” or geographical clusters of high social vulnerability and high fire risk. The researchers ran regression analysis at two additional levels for Alabama and South Carolina to verify their statistical findings. Finding their results consistent with existing literature, the authors conclude that there is an inverse association between social vulnerability and wildfire risk. However, the authors maintain that upper income migrants to WUIs do not necessarily cause greater fire risk, rather that irresponsible development coupled with limited fire mitigation programming results in greater vulnerability for low-income, rural populations. By thinking strategically about community-based wildfire mitigation initiatives geared to specific resident demographics, land managers can determine best practices for directing preparation and resilience programming to the places most in need of such efforts.

2013

Fischer, A. Paige, Travis Paveglio, Matthew Carroll, Daniel Murphy, and Hannah Brenkert-Smith. 2013. “Assessing social vulnerability to climate change in human communities near public forests and grasslands: A framework for resource managers and planners.” *Journal of Forestry* 111, no. 5 (2013): 357-365.

Main finding: The main challenges facing resource managers attempting to utilize existing methods (social vulnerability indicators, community case studies, and participatory scenario-building) of assessing social vulnerability to climate change involve applying anecdotal information to broad policymaking processes and employing quantitative data to study unique community contexts, where dynamic relationships make general data-driven policies incompatible. Balancing these concerns is key to assessing social vulnerability, whether through indicator indices, case studies, or scenario-building.

This paper presents a practical framework for measuring vulnerability to climate change in public forests and grasslands in the United States, responding to a lack of practical guidance for how resource managers can address hazard vulnerability generally and social vulnerability in particular. They rely on existing research on social vulnerability to environmental hazards, recognizing that social vulnerability presents an emerging concern for climate change policy. The authors recognize that as public land management agencies consider the role of social vulnerability in assessing and anticipating climate change impacts, the need for clear protocols for assessing social vulnerability in rural and urban contexts becomes increasingly pertinent. The authors present two categories of social vulnerability data: (1) profile information, which measures socioeconomic and geographic conditions regarding stress and risk and (2) process infor-

mation, which examines social relationships in communities. They examine the utility of both forms of information for resource managers and planners who are tasked with creating policies to address social vulnerability. The authors conclude that assessment methods should be tailored to the specific social and ecological conditions in the area they are studying, noting that indicator studies, community case studies, and participatory scenario-building are recognized methods of gathering both profile and process information. They contend that private and public agencies can use social vulnerability to understand the needs of communities facing climate change by contextualizing this framework to specific locations.

Prior, Tim and Christine Eriksen. “Wildfire preparedness, community cohesion and social–ecological systems.” *Global Environmental Change* 23, no. 6 (2013): 1575-1586.

Main finding: Despite differing theories of vulnerability and resilience, individuals are more likely to proactively mitigate wildfire risk when they feel a sense of belonging or social cohesion. This results in a lesser need for management intervention on the part of institutions and fosters community hazard resilience in the face of increasing wildfire risk.

This research examines the effects of social cohesion on community wildfire preparation as wildfire is an increasingly global issue in the wake of higher wildfire occurrences resulting from changing climate conditions in forest ecosystems. The authors argue that a sense of community and collective problem solving positively impact a community’s likelihood to collaboratively prepare for wildfire and increase their wildfire resilience. The research involves a series of interviews and surveys of wildland-urban interface communities in Australia that the authors use to construct a substantive model to measure how social cohesion informs community decisions to prepare for wildfire. The researchers collected quantitative data from households within 100 meters of wilderness in two regions: outside Hobart (Tasmania) and Sydney, Australia. They argue that “sense of community” and “collective problem solving” can be seen as community-based resources that reinforce the implementation and development of preparatory and cognitive capacity to reduce vulnerability and increase resilience to wildfire. Even though theories of vulnerability and resilience vary across disciplines and thus vary among stakeholders, the authors contend that land managers can effectively facilitate community and individual efforts toward resilience by fostering social cohesion, which allows communities to self-manage their wildfire resilience. Such cohesion reduces public reliance on international action by empowering local communities, which may successfully foster adaptive capacity to climate change impacts and general natural hazard vulnerability. Therefore, policy makers and land managers can enact effective and sustainable solutions to environmental problems at local levels by being mindful of social attitudes, beliefs, values, and emotional approaches to the environment and to each community’s unique conditions of vulnerability and resilience.

Simon, Gregory L. and Sarah Dooling. “Flame and fortune in California: The material and political dimensions of vulnerability.” *Global Environmental Change* 23, no. 6 (2013): 1410-1423.

Main finding: Considering vulnerability in terms of political dynamics (such as policies affecting biomass management that are put to referendum), historical developments (such as deforestation or residential development), and biophysical hazards offers a more nuanced representation of vulnerability. Hazard vulnerability is not a standalone phenomenon but part of a broader set of vulnerabilities that are interconnected and that affect one another, by either maintaining, worsening, or diminishing the conditions of vulnerability.

This study looks at material vulnerability in California, particularly leading up to the 1991 Oakland Hills Firestorm. The authors present a vulnerability framework that considers historical development, land management, and political impacts on fire hazard in the Oakland Hills to shed light on fire concerns for California at large, given the state’s increasingly severe fires. They argue that considering vulnerability

in terms of political dynamics (such as policies affecting vegetative fuels management that are put to referendum), historical developments (such as deforestation or residential development), and biophysical hazards offers a more nuanced representation of vulnerability. They contend that vulnerability, taken this way, can be examined as a recursive process. In order to support this hypothesis, the researchers develop a spatial-historical analytic approach that combines historical and economic analysis with empirical data. They use the 1991 Oakland Hills Firestorm/Tunnel Fire as a case study because of its historical status as the most destructive fire (in terms of dwellings lost) in California history. They argue that this case study and framework recognizes hazard vulnerability not as a standalone phenomenon but part of a broader set of vulnerabilities that are interconnected and affect one another, by either maintaining, worsening, or diminishing the conditions of vulnerability; therefore, holistic analyses such as this can help researchers and policymakers avoid maladaptive outcomes that increase risk despite well-intentioned but poorly informed policies.

2014

Maru, Yiheyis Taddelle, Mark Stafford Smith, Ashley Sparrow, Patricia F. Pinho, and Opha Pauline Dube. "A linked vulnerability and resilience framework for adaptation pathways in remote disadvantaged communities." *Global Environmental Change* 28 (2014): 337-350.

Main finding: While both vulnerability and resilience narratives are valid for approaching climate hazards affecting remote populations, they should not be taken in isolation—doing so can skew research and result in misguided assessments. Instead, constructing a framework that considers both vulnerability and resilience together, paired with a community-centered approach to assessment, can lead to productive adaptive pathways.

This article examines the possibilities that emerge from the two primary narratives regarding climate hazards affecting remote populations: adaptive capacity/resilience and social vulnerability. The authors argue that both resilience and vulnerability narratives provide valid approaches to addressing hazards for remote peoples, but that taken in isolation, each narrative can misguide practices, policies, and research. Resilience narratives represent the local knowledge of primarily indigenous populations and their connections to environments, which contribute to their adaptive capacity; however, overemphasizing resilience narratives can minimize the disadvantages that remote peoples face, including lack of access to resources and lack of agency over policy. On the other hand, vulnerability frameworks conceptualize hazards in their larger social and political contexts, targeting the drivers of vulnerability for marginalized populations; however, strictly following vulnerability frameworks can fail to recognize the rich knowledge of remote populations and their potential to enact collective change to improve their adaptability. The authors contend that approaching vulnerability and resilience through a joint framework can help policymakers and communities establish adaptation pathways that are responsive to the specific contexts and circumstances with which remote populations contend. They perform a literature survey to support this joint resilience-vulnerability framework, creating feedback loop schematics and applying those schematics to three case studies to support their hypothesis based on specific climate regions and remote populations in Australia, Botswana, and Brazil. In Australia, the researchers held a workshop that brought together academics, policymakers, indigenous leaders, and local residents to determine hazard exposure and adaptive responses, particularly assessing whether vulnerability or resilience dominates their adaptive capacity. In the case of fire, the working group found that resilience dominated vulnerability, while in the case of flood, vulnerability dominated resilience. Through this process, the researchers were able to separate resilience from vulnerability in two specific climate scenarios, which resulted in more specific assessment of vulnerability and resilience and facilitated more specific adaptive pathways toward empowering remote, marginalized communities. This framework, they argue, is more productive than policy-based assessments and conceptual methods that are removed from the communities.

2015

Abrams, Jesse B., Melanie Knapp, Travis B. Paveglio, Autumn Ellison, Cassandra Moseley, Max Nielsen-Pincus, and Matthew S. Carroll. "Re-envisioning community-wildfire relations in the US West as adaptive governance." *Ecology and Society* 20, no. 3 (2015): 34: 1-13.

Main finding: Community resilience can be understood as a form of adaptive governance, with institutions across multiple scales offering valuable opportunities and potential for increasing community resilience through learning and adaptation processes.

This research approaches community-level resilience to wildfire as a process of adaptive governance that is significantly affected by institutions at multiple scales and benefits from learning across those scales. Rather than positioning communities and community members as isolated actors or as fully autonomous decision makers, the authors contend that community resilience arises from a number of conditions and influences, including social-ecological systems, forest and fire institutions, government agencies, and commonly researched conditions of social vulnerability. The authors perform a case study of two communities in wildfire-prone areas—Caughlin Ranch, Nevada and Raton, New Mexico—to determine the extent of institutional influence on adaptive capacity. The researchers analyzed data collected in roundtable discussions and utilized interview transcript coding to establish analytic narratives of each case study. Each case study yielded different insights. The Caughlin Ranch study suggested that homeowners' associations are important to structuring wildfire adaptation, but that such structures require institutional incentives for learning and adaptation in order to avoid the diffusion of responsibility among residents. On the other hand, the Raton study suggested that agencies on multiple scales can increase social capital and wildfire adaptability through interactive learning forums. The authors conclude that many of the social relationships that inform community resilience to wildfire are valid and important, but neglecting to consider institutional and organizational roles in adaptability misses a key factor in resilience. Fire resilience, according to this research, is less about preparation on an individual level and more about adaptive governance of ecological and social systems across neighborhoods, communities, and regions.

Murphy, Daniel J., Carina Wyborn, Laurie Yung, and Daniel R. Williams. "Key concepts and methods in social vulnerability and adaptive capacity." *Gen. Tech. Rep. RMRS-GTR-328*. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 p. 328 (2015).

Main finding: Social vulnerability and adaptive capacity are increasingly important aspects of forest management due to increased impacts of climate change. Forest Service personnel should familiarize themselves with the various methods of conceptualizing and assessing vulnerability and make strategic choices as to how they plan around vulnerability.

This USDA-funded report provides an updated overview of disciplinary approaches to social vulnerability and adaptive capacity, presenting the benefits and limitations of each research approach and the methods offered by each approach. The authors contend that social vulnerability and adaptive capacity are increasingly important issues for land managers, particularly Forest Service personnel, to attend to given the impacts of climate change. They consider the different contextual issues at play in assessing and planning around vulnerability—including local economic forces, community knowledge and agency, social dynamics, biophysical conditions, and global impacts on local circumstances. The authors identify four conceptual frameworks driving social vulnerability research: (1) actor-oriented (viewing actors as "exposure units" that follow rational decision-making processes); (2) systems-oriented (focusing on exposure and resilience based on relationships between actors and the systems around them); (3) outcome-oriented

(measuring impacts of hazards on individual exposure units); and (4) context-oriented (focusing on the spatial and temporal dimensions that affect vulnerability and adaptability). Each of these approaches provides opportunities and limitations in assessing and/or representing vulnerability, and each yields a degree of ambiguity or convolution. Yet the authors contend that in certain situations, actor-oriented, systems-oriented, outcome-oriented, or context-oriented frameworks (or some combination thereof) can serve as useful tools for approaching hazard vulnerability. The authors also provide an overview of the prominent assessment methods with their relevant conceptual approaches: (1) dose-response, (2) indices and indicators, (3) case studies, (4) scenario-building, and (5) participatory. These methods provide useful means of rendering vulnerability visible, but the authors stress the importance of ethical considerations, including what it means to label a community or population as “vulnerable,” particularly because such labeling could undermine their sense of agency toward adaptive capacity. Thus, context and strategic methodological choices are crucial for effectively mediating hazard vulnerability.

2016

Carroll, Matthew and Travis Paveglio. “Using community archetypes to better understand differential community adaptation to wildfire risk.” *Philosophical Transactions of the Royal Society B: Biological Sciences* 371, no. 1696 (2016): 1-7.

Main finding: WUI communities reflect a diverse range of resident dynamics regarding environmental knowledge, willingness to accept government intervention, and dependence upon natural resources. Research that considers these community dynamics as archetypes to wildfire risk management will be better suited to harness local knowledge and foster adaptive capacity.

This article provides an example of how to construct representative articulations of wildland-urban interface (WUI) community dynamics, which the authors argue can help to productively combine local knowledge and experience with wildfire risk research. The authors argue that wildfire risk is largely driven by relationships between biophysical and social systems, and that risk is subject to the interconnectedness and collective knowledge of local communities. The authors contend that wildfire risk strategy must take into consideration community knowledge and attitudes toward the land and toward wildfire. To facilitate this process, the authors offer four archetypes as loose, generalized groupings of WUI residents and their connections to the environment: (1) formalized suburban WUI communities, made up of affluent, professional commuters who may not know much about fire adaptation practices; (2) high amenity/high resource WUI communities, made up of professionals with a mix of skills related to land management and fuel reduction practices; (3) rural lifestyle WUI communities, made up of residents who seek rurality as a way of life and who construct a sense of community among other rural populations; and (4) working landscape/resource dependent WUI communities, made up of people who have continued to rely on environmental resources following initial European settlement of Western territories. Each of these groupings reflect different levels of knowledge related to land and fire management, different levels of acceptance or distrust of government policies or regulation, and different levels of interest in collaborating with outside organizations to reduce fire risk. The authors briefly examine the implications of these community dynamics in two case studies in Nevada and Washington. From this model and these studies, the authors recommend that researchers develop regionally specific approaches to wildfire risk management that are attentive to community dynamics and include local knowledge and community organizations in development of strategies addressing natural resource problems. Finally, they argue that this direction for research, comprehensively considering biophysical hazards, climate change, adaptive capacity, and social vulnerability, should come out of relationships grounded in community.

Paveglio, Travis B., Tony Prato, Catrin Edgeley, and Derek Nalle. "Evaluating the characteristics of social vulnerability to wildfire: Demographics, perceptions, and parcel characteristics." *Environmental Management* 58, no. 3 (2016): 534-548.

Main finding: Social vulnerability metrics are not universally applicable, especially in wildfire hazard areas. Holistic research and assessment must account for residents' tenure, relationship with and perception of their environment, and degree of wildfire exposure.

This research offers a rigorous case study of wildfire vulnerability in Flathead County, Montana in order to evaluate what characterizes hazard vulnerability. Building on social vulnerability research, the authors use surveys, wildfire simulations, and GIS data to examine demographic, perceptual, and parcel characteristics against data produced by simulations. The authors find that demographic characteristics, which typically underscore social vulnerability analyses, do not prove significant in measures of wildfire exposure and vulnerability. They find that residency (part-time or full-time), perceived private property risk, age, and development timing were the most significant determinants regarding fuel reduction and risk mitigation by residents. In order to produce these findings, the authors created a new method for detecting and tracking fine-scale characteristics affecting wildfire vulnerability to determine degree of exposure. This method involved spatially tailored, parcel-level data and metrics, which produced more detailed evaluative data than previous studies. Particular attention to spatial dynamics at the parcel level, combined with survey methodology, allowed the researchers to identify the specific variables affecting vulnerability rather than applying preexisting variables to their case study. While the authors affirm that wildfire vulnerability research lacks consistent assessment methods, they contend that their methods can be useful for evaluating and comparing wildfire impact across regions. They argue that effective assessments must consider different dependent variables that apply to particular circumstances and regions in order to create an accurate picture of social vulnerability to wildfire.

Smith, Alistair M.S., Crystal A. Kolden, Travis B. Paveglio, Mark A. Cochrane, David MJS Bowman, Max A. Moritz, Andrew D. Kliskey, et al. "The Science of firescapes: Achieving fire-resilient communities." *Bioscience* 66, no. 2 (2016): 130-146.

Main finding: Community resilience to wildfire is best supported by research that looks at human-fire interactions holistically through a risk-to-resilience continuum incorporating risk, adaptation, mitigation, and resilience. Most research considers each of these concepts in isolation or otherwise fails to consider firescapes holistically; this framework can provide a broadly applicable guideline for strategy discussions starting at the ground level.

This research provides an overview of the perspectives guiding wildfire research, which the authors see as limited due to organizational tendencies to isolate approaches, methodologies, and practices based on disciplinary conventions. The authors argue that current research is untenable when it comes to addressing adaptation and mitigation challenges and to reintegrating fire as a management practice. They see wildfire risk as the merger between two concepts: (1) shared human population values that are affected by wildfire, elsewhere referred to as adaptive capacity, and (2) biophysical conditions that affect the probability of wildfire and its intensity. The authors contend that these concepts are usually examined separately and should be integrated in order to develop collective, concrete definitions and strategies for managing fire-affected landscapes. They offer a risk-to-resilience framework to guide discussions about wildfire risk and to facilitate mitigation strategies by communities and organizations. This broadly applicable framework recognizes gaps in knowledge that limit community prediction, adaptation, and mitigation of wildfire; it also situates scientific knowledge in relation to on-the-ground needs. The authors propose a concept of

wildfire-affected landscapes or “firescapes,” which they argue reflect human-natural systems and their impact on wildfire processes more holistically; feedback resulting from analyses of firescapes help capture the cascading consequences of management decisions and human-fire interactions. They argue that organizations and communities should focus on four points of the risk-to-resilience framework in order to reduce vulnerability and increase resilience: (1) risk, (2) adaptation, (3) mitigation, and (4) resilience. The authors see this framework as a continuum, and advocate for definition, planning, and strategizing responses and principles related to each point on the framework. They also argue that further study of risk and resilience should incorporate local and indigenous knowledge to further foster adaptation. The authors close by identifying five ongoing challenges for achieving fire-resilient communities: (1) characterizing firescape vulnerability; (2) identifying cascading fire consequences; (3) identifying early warning signals of firescape vulnerability; (4) promoting standards and preparing for shifted ecosystem states; and (5) addressing barriers and achieving firescape resilience.

Wigtil, Gabriel, Roger B. Hammer, Jeffrey D. Kline, Miranda H. Mockrin, Susan I. Stewart, Daniel Roper, and Volker C. Radeloff. “Places where wildfire potential and social vulnerability coincide in the coterminous United States.” *International Journal of Wildland Fire* 25, no. 8 (2016): 896-908.

Main finding: On average, places with high wildfire potential had lower social vulnerability, but approximately 10% of areas classified as high wildfire potential were also classified as having a high occurrence of socially vulnerable populations. Assessing or mapping social vulnerability and wildfire potential in concert can direct attention and resources to the most socially vulnerable populations also at high physical risk to wildfire.

This research examines the overlap of social vulnerability and wildfire exposure. The authors follow a hazards-of-place model, which considers vulnerability as a combination of biophysical and social factors. Following Susan Cutter’s social vulnerability indices (2003), the researchers map vulnerability by household in the coterminous United States and overlap that data with wildfire potential, with consideration for WUI populations. They use 26 socioeconomic and demographic variables to determine social vulnerability on an aggregate scale, and created a social vulnerability index using census block data from the 2006-2010 American Community Survey and the 2010 US Census. They combined this index with data from the Forest Service Wildland Fire Potential dataset. The authors’ mapping procedure and results, they argue, can direct attention and resources to the most socially vulnerable populations that are also at high physical risk to be impacted by fire. Although their findings suggest wildfire risk and social vulnerability are not necessarily related conditions, the authors argue that this kind of mapping can identify those at the greatest risk and can help balance resource access in ever-increasingly diverse and growing WUI communities.

Wigtil et al. carefully considered the limitations of their complex research design and discussed its potential drawbacks in detail, yet a cursory reading of their paper could still provide misleading conclusions. Consequently, their hazards-of-place approach provides a good illustration of the importance of examining authors’ methodological choices. The authors combined census block-level WUI designations, census block group-level socioeconomic data (as a measure of social vulnerability) with a spatially explicit classification of wildfire potential. Census blocks are the smallest aggregate geographic units used in the US Census and census block groups are clusters of census blocks. Blocks and block-groups are spatially irregular and highly variable, with boundaries determined by roads and waterways, and sizes and shapes related to the number of people they contain (block-groups range from 600-3,000 people). Following Cutter, Boruff, and Shirley (2003), Wigtil et al. created a composite social vulnerability index (SVI) for each census block, normalized the SVI score, then classified the results into low (< -1.0), moderate (-1.0 to 1.0),

and high (> 1.0) social vulnerability. The wildfire potential map is a 7.29 ha cell, non-ordinal classification with seven different categories. To combine these two types of spatial data, Wigtil et al. took the modal (most frequently occurring) wildfire potential class for each census block. Their results report that across the United States, approximately 10% of all housing units located in places they classified as having high wildfire potential also fall within census block groups classified as having “high” social vulnerability. However, this does not mean that 10% of houses in areas of high wildfire potential are actually socially vulnerable, nor does it mean that 10% of houses that are socially vulnerable are located in high wildfire potential cells. One problem is that housing units in a rural census block may not be located in or even adjacent to the modal wildfire potential cells. Another problem is that the SVI score is the composite at the block group level, meaning that one wealthy, densely populated neighborhood (a city or suburb) could skew the SVI toward low social vulnerability, even if the rest of the block group is rural and poor. The authors further reported that WUI blocks (aggregated nationally) had the lowest average normalized SVI score, but this actually means that more WUI blocks are located in census block groups with a lower average SVI; it does not mean that WUI blocks themselves have lower social vulnerability.

2017

Paveglio, Travis B., Max Nielsen-Pincus, Jesse Abrams, and Cassandra Moseley. “Advancing characterization of social diversity in the wildland-urban interface: An indicator approach for wildfire management.” *Landscape and Urban Planning* 160 (2017): 115-126.

Main finding: The study found a number of significant interactions between four composite indices—social cohesion, place-based knowledge, access to scientific and technical knowledge, and shared responsibility and understanding—and wildfire adaptation.

This research takes a quantitative approach to characterizing social diversity in “fire-prone” WUI communities and relating its progress toward wildfire adaptation. The authors used statistical factor and cluster analyses to examine interactions between key informant evaluations of fire adaptation and social contexts. Paveglio et al. conducted key informant interviews in nine states to assess the progress of communities towards achieving the status of “fire-adapted communities” (FACs) and local social contexts that contribute to community wildfire risk adaptation.

Key informants were interviewed based upon four factors: (1) social cohesion; (2) place-based knowledge; (3) access to scientific and technical knowledge; and (4) shared responsibility and understanding. Findings from interview responses indicated the critical importance of place-based knowledge, such as an understanding of the community’s wildfire risk and the role of wildfire in the ecosystem, in addition to access to community organizers that have scientific and technical knowledge of wildfire planning. Local leaders, or “spark plugs” are found to be an especially important source of scientific and technical knowledge for encouraging collective action and educating residents about local fire ecology. The combination of these characteristics reinforce one-another and contribute to more collective adaptive wildfire action outcomes within communities and progress towards status as a FAC. This research further demonstrates that communities respond and adapt to wildfire based upon the interrelated characteristics and social contexts of individual communities, including local experiences, perspectives, and preferences. This article provides a framework for gauging the level of wildfire adaptation and determining how understanding the local context can help enact wildfire management strategies within different communities.

2018

Davies, Ian P., Ryan D. Haugo, James C. Robertson, and Phillip S. Levin. “The unequal vulnerability of communities of color to wildfire.” *PLoS one* 13, no. 11 (2018): e0205825.

Main finding: The study found that 29 million Americans live in census tracts with significant exposure to extreme wildfires. While most of these are socially and economically secure, about 12 million Americans live in census tracts with poor adaptive capacity. The authors also found correlations between minority populations and increased vulnerability.

Davies et al. take a “socio-ecological” approach to wildfire vulnerability across 70,000 census tracts. This approach incorporates wildfire potential and socioeconomic proxies for wildfire vulnerability and adaptive capacity, using US Census data to assess adaptive capacity as the inverse of social vulnerability in conjunction with the US Forest Service’s Wildfire Hazard Potential of census tracts within the continental US. The adaptive capacity index included 13 variables, such as persons below poverty level, unemployment, per capita income, vehicle ownership, education level, etc. Under the assumption that lower income households are less likely to be able to prepare or recover from a wildfire, Davies et al. seek to assess which communities are most vulnerable to wildfire. By examining the relationship between a census tract’s wildfire likelihood (exposure), socioeconomic status (susceptibility), and race/ethnicity, the authors found Black and Native Americans were most likely to be overrepresented in communities prone to wildfire (with high exposure) and with low socioeconomic status. In comparison, Davies et al. found that majority white or Asian/Pacific Islander communities were most represented in the most secure/least vulnerable census tracts. This article confirms the author’s premise that socially disadvantaged populations have the least adaptive capacity and are the most vulnerable to wildfire.

Fischer, Alexandra Paige, and Tim G. Frazier. “Social vulnerability to climate change in temperate forest areas: New measures of exposure, sensitivity, and adaptive capacity.” *Annals of the American Association of Geographers* 108, no. 3 (2018): 658-678.

Main finding: Using a social vulnerability framework, the authors found high exposure to climate-related changes in 24 counties in Washington and Oregon, with nature of exposure varying across space.

This study employs a social vulnerability framework to examine the climate-change related vulnerability of communities in forested areas. The authors focused on 75 counties in Oregon and Washington with temperate forest ecosystems. In addition to measures of “projected exposure” and “sensitivity”, the authors add a measure of “adaptive capacity” to the social vulnerability framework in order to account for how communities may mitigate exposure and sensitivity to climate change. To determine the exposure of each county to climate-related changes, the authors created an index based on the projected change of four components in forest ecosystems: (1) forest vegetation type, (2) carbon stocks, (3) large wildfire suitability, and (4) insect and disease mortality. The authors determined sensitivity based upon socioeconomic status in addition to the extent each community depended on forest resources, calculated by measuring the concentration of forest sector employment within a county. Adaptive capacity was based upon “access to resources, social cohesion, opportunities for learning about and investing in behavioral change, and existences of supportive social institutions”. The study found that one-third of the counties studied were especially vulnerable and that nine of those lacked adaptive capacity. Although the authors do not deal specifically with social vulnerability to wildfire, they do include change in wildfire hazard as an exposure measure. Further, their use of an adaptive capacity measure is of interest to this synthesis because it allowed the authors to identify counties that may be especially vulnerable to climate-related changes to forests, including predicted increases in intensity and occurrence of wildland fire, and may be useful for informing future climate adaptation policies in vulnerable communities.

Paveglio, Travis B., Catrin M. Edgeley, and Amanda M. Stasiewicz. “Assessing influences on social vulnerability to wildfire using surveys, spatial data and wildfire simulations.” *Journal of Environmental Management* 213 (2018): 425-439.

Main finding: The authors find that elements contributing to social vulnerability to wildfire operate at small scales and thus question the utility of US Census block scale analyses.

This study uses surveys, GIS data, and computer simulations to model variability in wildfire exposure and sensitivity. The paper extends the Paveglio et al. 2016 approach (see above). Rather than assessing social vulnerability by measuring exposure, sensitivity, and adaptive capacity at a large geographic scale, the study provides a novel approach to evaluating wildfire vulnerability indicators at the parcel level within a five-mile area. Through self-reported surveys, risk simulations of individual residential parcels, and parcel data, the author’s assess and yield a high resolution and spatially explicit view of an individual community’s social vulnerability. The authors wished to determine whether the common assumptions and results seen in previous social vulnerability studies of large geographic areas were consistent with results at smaller scales. Their findings indicated that aggregate assessments in many cases do not capture the true social vulnerability of a population. Their findings further support previous studies finding higher-income residents tend to live in more fire-prone locations but differ by suggesting this indicates high-value properties are more socially vulnerable. The authors found some correlation between the newer, elderly, and part-time homeowner demographic and lower adaptability, but recommended further investigation. However, within the study area region, the authors found exposure, risk, and adaptive capacity to vary significantly. The authors suggest prioritization of dialogue between potential homeowners about the inherent risk of buying a home in a fire prone area and suggest that residents may be more likely to perform fire mitigation action on their property if dis-incentivized through taxation. The authors recognize the limitations of such a fine-scale study for making assumptions about the greater U.S. population and recommend further fine-scale studies, recognizing that social vulnerability of a community is multi-faceted and based upon the values of each individual, local population.

2019

Carroll, Matthew S., and Travis Paveglio. “Local Community Agency and Vulnerability Influences on a Montana Wildfire.” *Journal of Forestry* 117, no. 2 (2019): 104-113.

Main finding: Long-term processes, such as settlement patterns and lack of planning with respect to wildfire risk, contributed most to social vulnerability by increasing exposure. Further, a culture of “individualism” prohibited collective action to mitigate fuels.

This paper presents a case study of settlement patterns and events that helped shape the social vulnerability of community members to a devastating wildfire in the Bull Mountains of central Montana. The authors conducted semi-structured interviews and a systematic qualitative analysis of interview transcripts to discern pre-existing community characteristics and ongoing social dynamics contributing to wildfire events being experienced in a local area as either a severe or catastrophic event. Interviews focused on individuals’ backgrounds, experiences of the fire and recovery, as well as their perceptions about how the local context and social dynamics influenced fire outcomes. The authors interviewed both residents and local officials involved in the event, asking question regarding the interviewee’s history within the area, their experience during the fire and recovery, and their view of local conditions affecting the impact of the wildfire. The authors discuss several common interview responses that likely contributed to the devastating nature of the wildfire: the influx of new residents to fire-prone areas without knowledge

of fire mitigation or its importance; the risky location of homes and subdivisions in the Bull Mountains; low participation rates in local fire prevention programs; and lack of fire insurance amongst homeowners. These underlying dynamics in addition to a culture of individualism in the community is attributed by the authors as increasing the vulnerability and sensitivity to wildfire. The authors' results suggest that local land managers should be aware of these factors and how they influence the community's adaptive capacity to wildfire and disposition towards performing fire mitigation measures upon their property. Further, these findings attest the emerging importance of including a community's perception of risk and its cultural characteristics within social vulnerability studies.

Palaiologou, Palaiologos, Alan A. Ager, Max Nielsen-Pincus, Cody R. Evers, and Michelle A. Day. "Social vulnerability to large wildfires in the western USA." *Landscape and Urban Planning* 189 (2019): 99-116.

Main finding: Socially vulnerable populations are unequally affected by wildfire due to structure and population density in exposed locations. By determining where the most vulnerable populations are located through quantitative methods, federal land managers can more efficiently prioritize and execute wildfire protection investments in socially vulnerable communities.

Palaiologou et al. (2019) quantify wildfire exposure using the US Census Social Vulnerability Index in conjunction with fire behavior simulations to determine fire transmission patterns and determine how land ownership affects socially vulnerable populations. Using a methodological framework, the authors seek to (1) determine where fires originate and how they travel through the landscape based upon land tenure and fuel, and (2) assess which populations are most vulnerable to wildfire originating on neighboring public lands. Based upon the presence of a large amount of public lands and high potential for wildfire risk, the study was conducted in three western states: north-central Washington, central California, and northern New Mexico. The authors generated Social Vulnerability Indexes (SoVIs) for US Census block groups (BGs) in the study area. The SoVIs were based on 21 social attributes, including, median household income, age, education, and housing type. Thousands of hypothetical wildfire simulations were conducted using Fire Simulation System (FSim) models to quantify predicted fire perimeters within each study area and exposure was calculated by combining predicted fire perimeters with WUI, land tenure, and Census data. The authors found that larger uncontrolled fires are the most common cause of structure exposure and mostly like to travel through multiple land tenures in all study areas, and socially vulnerable BGs were more exposed per area burned by fire due to their population and structure density. The strength of this study's approach is that it gives managers the ability to estimate exposure and sensitivity at different spatial scales using the SoVI. It also helps target at-risk populations for education and outreach about fire mitigation strategies.

