Social Science and Fire Weather 2003-2021

Bibliography

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Table of Contents

Background & Scope

Wildfires are increasing and there is a large demand on the fire weather community. The Weather Program Office Social Science Program is interested in prior social science work that has been conducted surrounding fire weather and NWS fire weather products/communication. This bibliography will help the team better understand if there are any gaps that would be ripe for future projects in this area and if so, what the projects would entail. This bibliography is arranged into the following broad categories: Preparedness and Mitigation Behaviors, Evacuation Modeling and Behavior, Risk Perception, Visualization & GIS Mapping, Risk Communication & Warnings, Decision Support & Incident Management, Fire Weather Forecasting, Products, and Services, Other.

Preparedness and Mitigation Behaviors

This category includes topics that pertain to various preparedness and mitigation behaviors that are frequently discussed in the context of Fire Weather. These topics may include, but are not limited to defensible space, fuel and fire management, and fire adapted communities.

Evacuation Modeling and Behavior

This category includes topics that pertain specifically to wildfire and fire weather evacuation decisions. Therefore, these topics include understanding people's evacuation decisions and/or modeling evacuation behaviors in the context of wildfires.

Risk Perception

This category includes topics that relate to people's risk perception associated with wildfires and/or fire weather. This often includes examining people's perception of the probability that the event will affect them personally, as well as the severity of the impacts.

Risk Communication & Warnings

This category includes topics pertaining to wildfire and fire weather risk communication best practices, message creation, public response to alerts and warnings, as well as WEA or short messaging recommendations/challenges associated with fire weather and wildfire hazards.

Decision Support & Incident Management

This category includes topics pertaining to wildfire and fire weather decision support, incident management teams, and fire management recommendations/challenges.

Fire Weather Forecasting, Products, and Services

This category includes topics that pertain to fire weather forecasting, as well as fire weather products and services. This includes topics such as verification of fire weather products and services, development of new products and services that are beneficial for fire weather forecasting, and the use of satellite observations for improving fire weather forecasting.

Other

This category includes all other fire weather topics that did not fit into the above categories.

Sources Reviewed

Along with a web search for relevant grey literature materials, the following databases were used to identify sources: Clarivate Analytics' Web of Science: Science Citation Index Expanded, ProQuest's Earth-Atmospheric & Aquatic Science Database, Science Direct, JSTOR and EBSCOs Academic Search Complete. Only English language materials were considered.

Preparedness and Mitigation Behaviors

Brenkert-Smith, H. (2010). Building Bridges to Fight Fire: The Role of Informal Social Interactions in Six Colorado Wildland-Urban Interface Communities. *International Journal of Wildland Fire, 19*(6), 689-697 https://doi.org/10.1071/WF09063

Property owners in fire-prone communities have been identified as key stakeholders in the wildfire dilemma. Although past research has examined stakeholder characteristics and their behaviours, less is known about how small-scale social processes among stakeholders might shape mitigation decision-making and related actions. This manuscript highlights the role informal social interactions play in building bridges among full-time and part-time residents that facilitate the spread of wildfire information and galvanise small-scale cooperative efforts to reduce wildfire risk. Data from in-depth interviews conducted with residents in six fire-prone Colorado communities indicate that these interactions create bridging capital that links those who are not likely to be the direct recipients of wildfire outreach efforts to those who are.

Brenkert-Smith, H., Champ, P. A., & Flores, N. (2012). Trying Not to Get Burned: Understanding Homeowners' Wildfire Risk-Mitigation Behaviors. *Environmental Management, 50*, 1139-1151 https://doi.org/10.1007/s00267-012-9949-8

Three causes have been identified for the spiraling cost of wildfire suppression in the United States: climate change, fuel accumulation from past wildfire suppression, and development in fire-prone areas. Because little is likely to be performed to halt the effects of climate on wildfire risk, and because fuel-management budgets cannot keep pace with fuel accumulation let alone reverse it, changing the behaviors of existing and potential homeowners in fire-prone areas is the most promising approach to decreasing the cost of suppressing wildfires in the wildland-urban interface and increasing the odds of homes surviving wildfire events. Wildfire education efforts encourage homeowners to manage their property to decrease wildfire risk. Such programs may be more effective with a better understanding of the factors related to homeowners' decisions to undertake wildfire risk-reduction actions. In this study, we measured whether homeowners had implemented 12 wildfire risk-mitigation measures in 2 Colorado Front Range counties. We found that wildfire information received from local volunteer fire departments and county wildfire specialists, as well as talking with neighbors about wildfire, were positively associated with higher levels of mitigation. Firsthand experience in the form of preparing for or undertaking an evacuation was also associated with a higher level of mitigation. Finally, homeowners who perceived higher levels of wildfire risk on their property had undertaken higher levels of wildfire-risk mitigation on their property.

McCaffrey, S. (2015). Community Wildfire Preparedness: A Global State-of-the-Knowledge Summary of Social Science Research. *Current Forestry Reports, 1*, 81-90 https://doi.org/10.1007/s40725-015-0015-7

This article builds on findings from a synthesis of fire social science research that was published from 2000 to 2010 to understand what has been learned more recently about public response to wildfires. Two notable changes were immediately noted in the fairly substantial number of articles published between 2011 and 2014. First, while over 90% of the articles found in the initial synthesis were US-based studies, roughly half of the articles published since 2010 have been conducted outside the USA,

the majority from Australia. Second, while the primary focus of earlier studies was on pre-fire mitigation efforts on both public and private lands, roughly half of the recent articles focused on dynamics during and after a fire. Overall, findings from the current review re-enforce key themes identified in the previous synthesis work and provide a deeper and more nuanced understanding of how certain variables, such as risk perception, may influence public response to wildfires. In addition, several important dynamics emerged across studies: the similarity of findings across countries, increased work across the temporal gradient, the importance of social interactions and of place attachment in shaping response, the need to take local knowledge and context into account, and the importance of financial support. These patterns suggest that while no single outreach approach or policy is likely to be effective everywhere or for everyone, efforts that facilitate development of relationships, within communities and between community members and fire personnel, can contribute to increased preparedness at the individual and community level by facilitating information exchange and helping to build a sense of community.

McCaffrey, S. M., & Rhodes, A. (2009). Public Response to Wildfire: Is the Australian "Stay and Defend or Leave Early" Approach an Option for Wildfire Management in the United States? *Journal of Forestry, 107*, 9-15 https://doi.org/10.1093/jof/107.1.9

In the United States, the increasing costs and negative impacts of wildfires are causing fire managers and policymakers to reexamine traditional approaches to fire management including whether mass evacuation of populations threatened by wildfire is always the most appropriate option. This article examines the Australian "stay and defend or leave early" (SDLE) approach (which is not inherently the same as shelter in place) and the contextual factors that may make it more or less appropriate in the United States. We first discuss what SDLE actually entails and then examine four contextual areas that could influence how appropriate the approach might be in the United States: nature of fire risk, agency roles and responsibilities, education and shared responsibility, and human dimensions and decision-making. Although some contextual differences may mean that there are US locations where the approach would be inappropriate, they are not systematic enough to mean that the approach would not be viable in many localities. However, significant groundwork would need to be laid to ensure success.

McCaffrey, S. M., Stidham, M., Toman, E., & Shindler, B. (2011). Outreach Programs, Peer Pressure, and Common Sense: What Motivates Homeowners to Mitigate Wildfire Risk? *Environmental Management, 48*, 475-488 https://doi.org/10.1007/s00267-011-9704-6

In recent years, altered forest conditions, climate change, and the increasing numbers of homes built in fire prone areas has meant that wildfires are affecting more people. An important part of minimizing the potential negative impacts of wildfire is engaging homeowners in mitigating the fire hazard on their land. It is therefore important to understand what makes homeowners more or less willing to take action. The research presented here comes from a study that interviewed a total of 198 homeowners in six communities in the western United States about the activities they had undertaken to mitigate their fire risk, the factors that contributed to their decisions, and their future intentions. The current paper reports on findings from the first half of the longitudinal study, after 3 years we will return to interview the current homeowner on the same properties to assess maintenance actions and facilitating and limiting factors. Overall we found a body of individuals who understand the fire risk, are taking numerous mitigation actions, and think that these actions have reduced their risk. These homeowners typically did not expect the government to do it for them: they wanted information about what to do

and, in some cases, assistance with the work, but saw taking care of their property primarily as their responsibility. Responses also show that key information sources and motivating factors vary by location and that it is not inherently necessary to have relationships between community members to create defensible space.

McCaffrey, S., Toman, E., Stidham, M., & Shindler, B. (2013). Social Science Research Related to Wildfire Management: An Overview of Recent Findings and Future Research Needs. *International Journal of Wildland Fire, 22* https://doi.org/10.1071/WF11115

As with other aspects of natural-resource management, the approach to managing wildland fires has evolved over time as scientific understanding has advanced and the broader context surrounding management decisions has changed. Prior to 2000 the primary focus of most fire research was on the physical and ecological aspects of fire; social science research was limited to a small number of studies. However, as more people moved into fire-prone areas interest grew in understanding relevant social dynamics. This growing interest was supported by increased funding for fire research overall with the creation of the Joint Fire Science Program in 1998 and the National Fire Plan in 2000. In subsequent years, a significant body of research has developed on the human dimensions of wildland fire covering diverse topics including: attitudes towards pre-fire mitigation, social acceptability of fire and fuels management, community preparedness, public response during fires, citizen–agency communications and post-fire recovery. This paper reports on two aspects of a Joint Fire Science Program project intended to take stock of the key social science lessons provided to date: a basic review of findings in the non-economic fire social science literature and identification of future research needs.

Neale, T., & Weir, J. K. (2015). Navigating Scientific Uncertainty in Wildfire and Flood Risk Mitigation: A Qualitative Review. *International Journal of Disaster Risk Reduction, 13*, 255-265 https://doi.org/10.1016/j.ijdrr.2015.06.010

Natural hazards are complex events whose mitigation has generated a diverse field of specialised natural science expertise that is drawn upon by a wide range of practitioners and decision-makers. In this paper, the authors bring natural science research, risk studies and science and technology studies together in aid of clarifying the role scientific uncertainties play in the mitigation of natural hazards and their associated risks. Given that uncertainty is a necessary part of scientific practise and method, those engaged in risk mitigation must manage these scientific uncertainties in their decision-making just as, equally, social science researchers, stakeholders and others hoping to understand risk mitigation must understand their character and influence. To this end, the authors present the results of an extensive literature review of scientific uncertainties as they emerge in relation to wildfire and flood risk mitigation in Australia. The results are both a survey of these major uncertainties and a novel categorisation within which a variety of expert and non-expert audiences might discuss and translate the scientific uncertainties that are encountered and managed in risk mitigation.

Nelson, K. C., Monroe, M. C., & Johnson, J. F. (2005). The Look of the Land: Homeowner Landscape Management and Wildfire Preparedness in Minnesota and Florida. *Society & Natural Resources, 18*, 321-336 https://doi.org/10.1080/08941920590915233

Many forest and fire agencies seek to influence homeowners to manage vegetation near their home to reduce wildfire risk. To be successful managers need to understand the range of existing landscape typologies based on a defensible space evaluation, homeowners' activities for wildfire preparedness, and what they value in landscape attributes. Interviews and visits with 80 homeowners at risk of wildfire in the wildland - urban interface of northern Minnesota and central Florida reveal that respondents managed for " naturalness,'' valuing their privacy, wildlife, aesthetics, and recreation. Five landscape typologies in Minnesota and four in Florida ranged from wide- open spaces to homes nestled in the deep woods. The valuing of naturalness was most closely linked to the tendency for a deep woods landscape. Respondents noted that how they manage for what they value as well as the ecosystem they live in partially explained their behavior in creating defensible space around their homes.

Paveglio, T. B., Carroll, M. S., Jakes, P. J., & Prato, T. (2012). Exploring the Social Characteristics of Adaptive Capacity for Wildfire: Insights from Flathead County, Montana. *Human Ecology Review, 19*, 110-124 Retrieved from https://www.jstor.org/stable/24707750

The increasing threat caused by wildfire in the United States has spurred the development of a number of policies and programs that encourage communities to reduce their risk by becoming "fire adapted." Yet despite these goals, there is little understanding of the characteristics that are crucial in the development of fire adapted communities. This research seeks to uncover specific aspects of local social context that lead to adaptive capacity for wildfire among communities in Flathead County, MT by consulting local fire professionals, community representatives and emergency managers using focus groups and interviews. Results suggest that adaptive capacity is highly variable across the county and influenced by aspects such as community identity, strong communication networks and the local wood products industry. We contend that a better understanding of adaptive capacity to wildfire requires systematic documentation of how specific characteristics of local people interact to influence their ability to deal with change.

Prior, T., & Eriksen, C. (2013). Wildfire Preparedness, Community Cohesion and Social–Ecological Systems. *Global Environmental Change, 23*, 1575-1586 https://doi.org/10.1016/j.gloenvcha.2013.09.016

The consequences of wildfires are felt in susceptible communities around the globe on an annual basis. Climate change predictions in places like the south-east of Australia and western United States suggest that wildfires may become more frequent and more intense with global climate change. Compounding this issue is progressive urban development at the peri-urban fringe (wildland–urban interface), where continued infrastructure development and demographic changes are likely to expose more people and property to this potentially disastrous natural hazard. Preparing well in advance of the wildfire season is seen as a fundamental behaviour that can both reduce community wildfire vulnerability and increase hazard resilience – it is an important element of adaptive capacity that allows people to coexist with the hazardous environment in which they live. We use household interviews and surveys to build and test a substantive model that illustrates how social cohesion influences the decision to prepare for wildfire. We demonstrate that social cohesion, particularly community characteristics like ‘sense of community’

and ‘collective problem solving’, are community-based resources that support both the adoption of mechanical preparations, and the development of cognitive abilities and capacities that reduce vulnerability and enhance resilience to wildfire. We use the results of this work to highlight opportunities to transfer techniques and approaches from natural hazards research to climate change adaptation research to explore how the impacts attributed to the social components of social–ecological systems can be mitigated more effectively.

Schulte, S., & Miller, K. A. (2010). Wildfire Risk and Climate Change: The Influence on Homeowner Mitigation Behavior in the Wildland-Urban Interface. *Society & Natural Resources, 23*, 417-435 https://doi.org/10.1080/08941920903431298

This project examines the sensitivity of behavior and attitudes regarding wildfire risk to perceptions of drought and climate change impacts, and documents the current state of homeowner risk mitigation effort in Clear Creek County, Colorado. Survey results demonstrate that homeowners have a fairly accurate understanding of the impact of climate change and other environmental risk factors, and that the majority have undertaken the most obvious risk mitigation investments, such as pruning vegetation around the home. Perception of climate and weather as risk factors has a significant impact on risk perception and concern about wildfire but is not a determinant of advanced mitigation effort. Further mitigation effort primarily relates to the value homeowners place on amenities associated with their house and their perception of the impact of neighboring lands mitigation.

Winter, G., McCaffrey, S., & Vogt, C. A. (2009). The Role of Community Policies in Defensible Space Compliance. *Forest Policy and Economics, 11*, 570-578 https://doi.org/10.1016/j.forpol.2009.07.004

Recently enacted federal and state policies provide incentives, including financial assistance, for local jurisdictions to manage risks associated with wildland fire. This has led to an array of local-level policies designed to encourage homeowners to create fire-safe landscapes. This qualitative study collected data from focus group interviews with homeowners in three diverse communities and used the theory of reasoned action to interpret dimensions of local-level wildland fire policies that are associated with homeowner acceptance of or compliance with defensible space guidelines or regulations. Common factors emerged in two policy evaluation categories: acceptance and compliance. WUI homeowners are more accepting of policies that are seen as fair and part of a more comprehensive risk reduction strategy. Topics that shaped acceptance of voluntary versus mandatory approaches included perceived risk severity, views about the proper roles of government, and beliefs about alternatives to regulatory approaches (e.g. private insurance, education, ignition source reduction). Program characteristics that were found to be related to beliefs about defensible space and acceptance included provision of one-on-one expert consultation, direct mail communication modes, needs-based financial assistance, and enhanced yard waste disposal options. Homeowner compliance is related to the feasibility in terms of household costs and yard waste disposal options, neighborhood norms, competing land use objectives, insurance considerations, and whether or not the policy is mandatory. These findings led to a proposed conceptual model of vegetation management policy acceptance and compliance that local governments can use to develop or amend defensible space vegetation management policies to increase policy acceptance and compliance.

Wolters, E. A., Steel, B. S., Weston, D., & Brunson, M. (2017). Determinants of Residential Firewise Behaviors in Central Oregon. *Social Science Journal, 54*, 168-178 https://doi.org/10.1016/j.soscij.2016.12.004

As a result of climate change and past management practices, wildfires are becoming larger and occurring more frequently than ever before in the Western U.S. In order to mitigate the effects of this growing threat, fire management agencies such as the U.S. Forest Service have encouraged residents in at-risk communities to protect their homes, property and communities by adopting Firewise recommendations. Using annual random sample household surveys conducted in fire-prone central Oregon from 2011 to 2013, this study examines the impact of wildfire events (i.e., wildfire exposure and evacuation), risk perception, wildfire plan informedness, proximity to wildlands, and various demographic factors on resident Firewise behavior participation. Findings indicate that residents who have experienced a wildfire event, who are familiar with their county's Community Wildfire Protection Plan, who perceive wildfire risk to their community, and who live in proximity or within a wildland area, were significantly more likely to engage in Firewise behaviors than those residents without these experiences, orientations or household locations.

Evacuation Modeling and Behavior

Cohn, P. J., Carroll, M. S., & Kumagai, Y. (2006). Evacuation Behavior during Wildfires: Results of Three Case Studies. *Western Journal of Applied Forestry, 21*(1), 39-48 https://doi.org/10.1093/wjaf/21.1.39

Evacuation of rural communities threatened by wildfires is occurring more often, particularly in the western United States. Residents, public safety officials, community leaders, and public land managers are facing the issues and problems of this news experience. We used semi-structured interviews to elicit the evacuation experience from the viewpoint of evacuees and public safety officials in three case studies of wildfire evacuations in the western United States during 2000 and 2002. (Our interviews were conducted only with Teller County, residents and officials.) We identify and describe the stages of the evacuation process as experienced by evacuees, and the dynamics and dilemmas associated with each stage. We analyze these perceptions and dynamics using the sociological lenses of social construction of meaning and structuration. The results indicate that evacuees and public safety officials have different perceptions and concerns about the evacuation process. We derive lessons learned from these three cases for use in planning future wildfire evacuations.

Cova, T. J., Dennison, P. E., & Drews, F. A. (2011). Modeling Evacuate Versus Shelter-in-Place Decisions in Wildfires. *Sustainability, 3*(10), 1662-1687 https://doi.org/10.3390/su3101662

Improving community resiliency to wildfire is a challenging problem in the face of ongoing development in fire-prone regions. Evacuation and shelter-in-place are the primary options for reducing wildfire casualties, but it can be difficult to determine which option offers the most protection in urgent scenarios. Although guidelines and policies have been proposed to inform this decision, a formal approach to evaluating protective options would help advance protective-action theory. We present an optimization model based on the premise that protecting a community can be viewed as assigning threatened households to one of three actions: evacuation, shelter-in-refuge, or shelter-in-home. While

evacuation generally offers the highest level of life protection, it can place residents at greater risk when little time is available. This leads to complex trade-offs involving expected fire intensity, available time, and the quality and accessibility of in-place shelter. An application of the model is presented to illustrate a range of issues that can arise across scenarios.

Cova, T. J., Drews, F. A., Siebeneck, L. K., & Musters, A. (2009). Protective Actions in Wildfires: Evacuate or Shelter-in-Place? *Natural Hazards Review, 10*(4), 151-162 https://doi.org/10.1061/(ASCE)1527-6988(2009)10:4(151)

The decision of whether to evacuate or shelter-in-place (SIP) in a wildfire poses a significant challenge for emergency managers and residents in fire-prone areas. Events such as the 2007 Witch Creek Fire and 2008 Tea Fire in California highlight the option and viability of SIP, as well as the conflict that can occur between first-responders and residents in protecting life and property. In general, anecdotes abound of people choosing SIP over evacuation in wildfires using a variety of means of refuge (e.g., structure, safe area, and water body). We propose a typology of wildfire protective actions that includes all viable forms of in-place shelter and discuss heuristics that have been proposed to guide people through the options. A key distinction is drawn between SIP as a backup plan when evacuation is perceived as too risky and SIP to improve structure survivability. Regardless of the form that SIP takes, the need for this strategy is growing as the wildland-urban interface expands. The paper concludes with a discussion of suggested areas for research and planning.

Folk, L. H., Kuligowski, E. D., Gwynne, S. M. V., & Gales, J. A. (2019). A Provisional Conceptual Model of Human Behavior in Response to Wildland-Urban Interface Fires. *Fire Technology, 55*, 1619-1647 https://doi.org/10.1007/s10694-019-00821-z

With more frequent and destructive wildfires occurring in the growing wildland-urban interface (WUI), the ability to ensure the safe evacuation of potentially large groups of people is of increasing importance. This is a challenging task made only more difficult by the fact that there is often little warning and that evacuations often need to take place in a short period of time. The creation of credible and effective evacuation models is needed within the fire safety engineering community to help address this challenge. Although potentially difficult to represent, a critical component in developing such models is the consideration of what people will do in response to a WUI fire. In this literature review, research relating to WUI fire evacuations was collected to identify the factors that influence protective action decision-making and response during these events, specifically whether someone chooses to evacuate or not. To supplement the findings, related hurricane evacuation literature was also reviewed for such factors. The factors that were identified relate to sociodemographic factors, social and environmental cues, preparation and experience, familial responsibilities, location, and credible threat and risk assessment. These factors were organized according to the Protective Action Decision Model (PADM) to create a conceptual model of protective action decision-making. This is the first step in being able to incorporate such factors and their corresponding impact on public response into comprehensive WUI evacuation models.

Fryer, G. K., Dennison, P. E., & Cova, T. J. (2013). Wildland Firefighter Entrapment Avoidance: Modelling Evacuation Triggers. *International Journal of Wildland Fire, 22*, 883-893 https://doi.org/10.1071/WF12160

Wildland firefighters are often called on to make tactical decisions under stressful conditions in order to suppress a fire. These decisions can be hindered by human factors such as insufficient knowledge of surroundings and conditions, lack of experience, overextension of resources or loss of situational awareness. One potential tool for assisting fire managers in situations where human factors can hinder decision-making is the Wildland-Urban Interface Evacuation (WUIVAC) model, which models fire minimum travel times to create geographic trigger buffers for evacuation recommendations. Utilising multiple combinations of escape routes and fire environment inputs based on the 2007 Zaca fire in California, USA, we created trigger buffers for firefighter evacuations on foot, by engine and by heavy mechanised equipment (i.e. bulldozer). Our primary objective was to examine trigger buffer sensitivity to evacuation mode and expected weather and fuel conditions. Evacuation travel time was the most important factor for determining the size and extent of modelled trigger buffers. For the examined scenarios, we show that WUIVAC can provide analytically driven, physically based triggers that can assist in entrapment avoidance and ultimately contribute to firefighter safety.

Kuligowski, E. (2021). Evacuation Decision-Making and Behavior in Wildfires: Past Research, Current Challenges and a Future Research Agenda. *Fire Safety Journal, 120* https://doi.org/10.1016/j.firesaf.2020.103129

Wildfires are becoming more common around the world, and households are frequently advised to evacuate when these fires threaten nearby communities. Effective evacuation requires an understanding of human behavior in wildfires, which is an area that needs further exploration. The purpose of this article is to present current research performed and data collected on evacuation decision-making and behavior during wildland-urban interface (WUI) fires, identify gaps in the research, and develop a future research plan for further data collection of important WUI fire evacuation topics. Research in this area can support developments of evacuation simulation models, and improvements in education programs, planning, decision-making, and design requirements for community-wide WUI fire evacuation.

Kuligowski, E. D., Walpole, E. H., Lovreglio, R., & McCaffrey, S. (2020). Modelling Evacuation Decision-Making in the 2016 Chimney Tops 2 Fire in Gatlinburg, Tn. *International Journal of Wildland Fire, 29*, 1120-1132 https://doi.org/10.1071/WF20038

As wildfires occurring at the wildland-urban interface (WUI) continue to become more severe, there is an increasing need to understand human behaviour in these situations, and evacuation decision-making in particular. To contribute to this understanding, an online survey (using both mail and online sampling methods) was disseminated to households impacted by the 2016 Chimney Tops 2 fire in Tennessee. The survey instrument measured pre-event variables such as awareness of fire risks and previous experience with evacuations as well as the types of warnings and fire cues received during the event, with a focus on factors known to impact evacuation decisions and risk perception. Using linear and logistic regression analyses, it was found that fire cues and receiving warnings from a trusted source influenced risk perceptions leading up to an evacuation decision. In line with the Protective Action Decision Model, risk perception also highly influenced evacuation decisions, along with other variables, i.e. gender and prior

preparation actions. Results from this work provide support for findings from previous wildfire evacuation research as well as produce some novel findings, along with several methodological recommendations, which will be further explored.

Lovreglio, R., Ronchi, E., & Nilsson, D. (2016). An Evacuation Decision Model Based on Perceived Risk, Social Influence and Behavioural Uncertainty. *Simulation Modelling Practice and Theory, 66*, 226-242 https://doi.org/10.1016/j.simpat.2016.03.006

The behaviour of people in the first stage of an evacuation can have a significant impact on the time required to reach a safe place. This behaviour is known in literature as pre-evacuation behaviour and it has been studied for many different evacuating scenarios. Despite the large number of studies, the representation of this behaviour is often oversimplified in most of the existing evacuation models. This paper aims to introduce a novel Evacuation Decision Model, allowing predicting the pre-evacuation state of an evacuee among three possible states (normal, investigation and evacuation) considering perceived risk for an evacuation scenario. The proposed model assumes that evacuees' perceived risk is affected by several environmental and social cues as well as by demographics and personal characteristics of evacuees. The concept of behavioural uncertainty is also included in the model and a formulation to calibrate the proposed model using a likelihood function is then provided.

McCaffrey, S., Rhodes, A., & Stidham, M. (2015). Wildfire Evacuation and Its Alternatives: Perspectives from Four United States' Communities. *International Journal of Wildland Fire, 24*, 170-178 https://doi.org/10.1071/WF13050

Recent years have seen growing interest within the United States fire management community in exploring alternatives to the standard approach of evacuating entire populations that are threatened by a wildfire. There has been particular interest in what can be learned from the Australian approach, whereby residents choose whether or not to evacuate under the 'prepare, stay and defend or leave early' approach, also called Stay or Go. Given these developments, it is useful to understand what elements are taken into consideration by those who would be most affected by a new approach when they think through the pros and cons of mass evacuation v. an alternative strategy should a wildfire occur. This paper reports on findings from interviews in four communities in the United States where some alternative to mass evacuation during a wildfire was being considered. In each community, emergency responders and community members were asked for their perspective on the pros and cons of evacuation and the alternative being considered. The results show that opinions were mixed on whether evacuation or an alternative approach was more appropriate. Individuals who were primarily thinking of improving safety and reducing uncertainty for emergency responders tended to think mass evacuation was the best approach, whereas those who were primarily thinking of increasing safety and reducing uncertainty for homeowners were more likely to think that alternative responses were a valid option. These findings demonstrate the complicated nature of developing evacuation strategies that are beneficial to all parties involved.

McLennan, J., Ryan, B., Bearman, C., & Toh, K. (2019). Should We Leave Now? Behavioral Factors in Evacuation under Wildfire Threat. *Fire Technology, 55*, 487-516 https://doi.org/10.1007/s10694-018-0753-8

Wildfires pose a serious threat to life in many countries. For police, fire and emergency services authorities in most jurisdictions in North America and Australia evacuation is now the option that is preferred overwhelmingly. Wildfire evacuation modeling can assist authorities in planning evacuation responses to future threats. Understanding residents' behavior under wildfire threat may assist in wildfire evacuation modeling. This paper reviews North American and Australian research into wildfire evacuation behavior published between January 2005 and June 2017. Wildfire evacuation policies differ across the two regions: in North America mandatory evacuations are favored, in Australia most are advisory. Research from both regions indicates that following a wildfire evacuation warning some threatened residents will wish to remain on their property in order to protect it, many will delay evacuating, and some residents who are not on their property when an evacuation warning is issued may seek to return. Mandatory evacuation is likely to result in greater compliance, enforcement policies are also likely to be influential. Self-delayed evacuation is likely if warnings are not sufficiently informative: residents are likely to engage in information search rather than initiating evacuation actions. The wildfire warning and threat histories of a location may influence residents' decisions and actions. The complexities of behavioral factors influencing residents' actions following an evacuation warning pose challenges for wildfire evacuation modeling. Suggestions are offered for ways in which authorities might reduce the numbers of residents who delay evacuating following a wildfire warning.

Mozumder, P., Raheem, N., Talberth, J., & Berrens, R. P. (2008). Investigating Intended Evacuation from Wildfires in the Wildland-Urban Interface: Application of a Bivariate Probit Model. *Forest Policy and Economics, 10*, 415-423 https://doi.org/10.1016/j.forpol.2008.02.002

With evidence of increasing wildfire risks in wildland-urban interface zones in the U.S. West and elsewhere, understanding intended evacuation behavior is a growing issue for community planners. This research investigates intended evacuation behavior due to wildfire risks, using mail survey data collected from over 1000 households in the East Mountain area outside Albuquerque, New Mexico (USA). Respondents were asked whether they would evacuate under both voluntary and mandatory evacuation orders. Bivariate probit probability models are used to jointly investigate the subjective belief structure of whether or not the respondent is concerned about wildfire risk, and the intended probability of evacuating as a function of risk perception, and a variety of socioeconomic and demographic variables (e.g. gender, political affiliation, length of residence, owning animals and amenity ratings).

Mutch, R. W., Rogers, M. J., Stephens, S. L., & Gill, A. M. (2011). Protecting Lives and Property in the Wildland-Urban Interface: Communities in Montana and Southern California Adopt Australian Paradigm. *Fire Technology, 47*, 357-377 https://doi.org/10.1007/s10694-010-0171-z

Threats to people and property in the wildland-urban interface have taken on global proportions. It is becoming increasingly rare to have a wildland fire incident that does not involve people and their homes. In addition to Australia and North America, people have died in interface fires in Europe, Africa, and Asia, including 212 people who died in the devastating forest fires in northeastern China in May 1987. The prevailing interface model is one that attempts to evacuate people away from fire areas to

get them out of harm's way. This traditional approach in the U.S. has been preferred by law enforcement agencies and fire services. The problem with this model is that evacuation warnings are often late to non-existent, leading to the deaths of interface residents entrapped by fires on highways as they try to escape. For example, 16 people suffered lethal burns when the 2003 Cedar and Paradise Fires in California overran them as they were trying to evacuate. Two communities in the United States have adopted variations of the Australian model of Prepare, Go Early, or Stay and Defend (P/GE/SD). Officials in the Painted Rocks Fire District, Montana, and Rancho Santa Fe, California, were interviewed to determine how the Australian model was being implemented. Two of the authors have firsthand experience with these two case examples. P/GE/SD has been tested successfully at both locations. The Australian model, however, is under review following the Black Saturday fires of February 2009 in Victoria, Australia. The objective of this paper is to present specific ideas that can be used to reform and improve fire policy, planning, and performance in the Wildland-Urban Interface in the United States.

Nguyen, C., Schlesinger, K. J., Han, F. Q., Gur, I., & Carlson, J. M. (2019). Modeling Individual and Group Evacuation Decisions During Wildfires. *Fire Technology, 55*, 517-545 https://doi.org/10.1007/s10694-018-0770-7

Quantifying factors that affect evacuation decision making remains a challenging task. Progress is crucial for developing predictive models of collective behavior and for designing effective policies to guide the action of populations during wildfires. We conduct a controlled behavioral experiment to probe factors influencing evacuation decision making in the face of an impending virtual wildfire. We consider competing factors that influence small groups and the community as a whole. Based on our data, we develop two distinct but complementary empirically-driven approaches to characterize individual and group evacuation decision making. Our first approach is a stochastic model that predicts evacuation of a population of individuals guided by the same decision-making strategy, which we define to be a continuous function of key experimental variables such as the likelihood of the disaster and the availability of resources. We extend this model to investigate strategy shifts leading to differences between individual and group behavior which manifest at the collective level. In our second approach, we characterize decision making of individuals and groups by incorporating variation in individual traits, group decision protocols, and time-dependent changes in experimental variables with logistic regression. By including personal identifying characteristics of each subject, we develop a model that can predict evacuation decision times with 85.0% accuracy. In parallel, we demonstrate that the social media activity of individual subjects, specifically their Facebook use, can be used to generate an alternative individual personality profile that leads to comparable prediction accuracy of 84.2%. Our results from both approaches demonstrate the importance of using a rate-based rather than threshold function to describe individual behavior, and of accounting for social influence and individual heterogeneity in modeling group decision making.

Paveglio, T., Prato, T., Dalenberg, D., & Venn, T. (2014). Understanding Evacuation Preferences and Wildfire Mitigations among Northwest Montana Residents. *International Journal of Wildland Fire, 23*(3), 435-444 https://doi.org/10.1071/WF13057

There is currently insufficient information in the United States about residents' planned evacuation actions during wildfire events, including any intent to remain at or near home during fire events. This is incompatible with growing evidence that select populations at risk from wildfire are considering alternatives to evacuation. This study explores the evacuation preferences of wildland-urban interface

residents in Flathead County, Montana, USA. We compare the performance of wildfire mitigation and fuel reduction actions across groups of residents with different primary evacuation preferences. We also explore what factors (e.g. actions, demographics, attitudes towards government, risk perceptions) help explain residents' preferences for evacuation. Results suggest that relatively high proportions of residents are interested in staying and defending their homes, with smaller proportions favouring evacuation or passively sheltering in their homes during wildfire. Vegetation management behaviour differs significantly among residents with different evacuation preferences, including significantly higher rates of forest thinning among those intending to remain at home and actively defend their residence. Other results suggest that sex, part-time residency, income and attitudes towards loss from fire are statistically associated with differences in evacuation preferences.

Stasiewicz, A. M., & Paveglio, T. B. (2021). Preparing for Wildfire Evacuation and Alternatives: Exploring Influences on Residents' Intended Evacuation Behaviors and Mitigations. *International Journal of Disaster Risk Reduction, 58* https://doi.org/10.1016/j.ijdrr.2021.102177

Understanding residents' intended evacuation behaviors is an increasingly important component of managing complex wildfire events in the United States and elsewhere. Growing evidence suggests that local populations consider a range of potential evacuation behaviors during fire events, yet fewer efforts explore rural residents' evacuation intentions or their relationship to wildfire mitigations that reduce risk or aid in fire suppression. This study explores evacuation intentions among wildland-urban interface residents in Pend Oreille County, Washington, USA. We explore how mitigation performance (e.g., fuel reduction efforts, structure improvements, active firefighting preparation) differs across three emergent categories of evacuation intentions and evaluate whether a range of factors correlate with participants' evacuation intentions. Our results suggest that a relatively high proportion of residents in the study area intend to stay and defend their property from a wildfire, with smaller proportions intending to evacuate or shelter in place. Individuals who intend to stay and defend are more likely to implement fuel reduction and property mitigation strategies when compared to those intending to evacuate or shelter in place. We found that elements of residency status, sex, age, presence of children in the home, and perceptions of personal efficacy and whether the property was prepared enough to not need firefighting were significant influences on group affiliation. For instance, part-time residency was significantly correlated with intending to evacuate, while full-time residents were more likely to stay and defend. Greater agreement that firefighting was not needed because a property was well-prepared was significantly related to staying and defending over evacuating.

Risk Perception

Champ, P. A., & Brenkert-Smith, H. (2016). Is Seeing Believing? Perceptions of Wildfire Risk over Time. *Risk Analysis, 36*, 816-830 Retrieved from https://onlinelibrary.wiley.com/doi/pdf/10.1111/risa.12465

Ongoing challenges to understanding how hazard exposure and disaster experiences influence perceived risk lead us to ask: Is seeing believing? We approach risk perception by attending to two components of overall risk perception: perceived probability of an event occurring and perceived consequences if an event occurs. Using a two-period longitudinal data set collected from a survey of homeowners living in a fire-prone area of Colorado, we find that study participants' initial high levels of perceived probability and consequences of a wildfire did not change substantially after extreme wildfire

events in the intervening years. More specifically, perceived probability of a wildfire changed very little, whereas the perceived consequences of a wildfire went up a bit. In addition, models of risk perceptions show that the two components of overall risk perception are correlated with somewhat different factors, and experience is not found to be one of the strongest correlates with perceived risk. These results reflect the importance of distinguishing the components of overall risk and modeling them separately to facilitate additional insights into the complexities of risk perceptions, factors related to perceived risk, and change in risk perceptions over time.

Champ, J. G., Brooks, J. J., & Williams, D. R. (2012). Stakeholder Understandings of Wildfire Mitigation: A Case of Shared and Contested Meanings. *Environmental Management, 50*, 581-597 Retrieved from https://link.springer.com/content/pdf/10.1007/s00267-012-9914-6.pdf

This article identifies and compares meanings of wildfire risk mitigation for stakeholders in the Front Range of Colorado, USA. We examine the case of a collaborative partnership sponsored by government agencies and directed to decrease hazardous fuels in interface areas. Data were collected by way of key informant interviews and focus groups. The analysis is guided by the Circuit of Culture model in communication research. We found both shared and differing meanings between members of this partnership (the "producers") and other stakeholders not formally in the partnership (the "consumers"). We conclude that those promoting the partnership's project to mitigate risk are primarily aligned with a discourse of scientific management. Stakeholders outside the partnership follow a discourse of community. We argue that failure to recognize and account for differences in the way risk mitigation is framed and related power dynamics could hamper the communicational efforts of the collaborative partnership and impact goals for fuels reduction. We recommend ways that both groups can capitalize on shared meanings and how agency managers and decision makers can build better working relationships with interface communities and other external stakeholders.

Cohn, P. J., Williams, D. R., & Carroll, M. S. (2008). Wildland-Urban Interface Residents' Views on Risk and Attribution. In *Wildfire Risk: Human Perceptions and Management Implications. .* W. E. Martin, C. Raish, & B. Kent (Eds.), (pp. 23-43). Washington, D.C.: Resources for the Future, RFF Press. Retrieved from https://www.fs.usda.gov/treesearch/pubs/29427

Catastrophic wildfires that impact human communities have become increasingly common in recent years. To reduce the potential for damage to human communities, wildland-urban interface (WUI) residents have been encouraged to perform mitigation or fire-safing measures around their homes and communities. Yet homeowners have not wholeheartedly adopted these measures, even after their communities have been struck by wildfire. Although some barriers to widespread adoption, such as the need for financial assistance and lack of knowledge, are being addressed, homeowner interest in adopting risk mitigation measures remains tepid.

Gordon, J. S., Matarrita-Cascante, D., Stedman, R. C., & Luloff, A. E. (2010). Wildfire Perception and Community Change. *Rural Sociology, 75*, 455-477 https://doi.org/10.1111/j.1549-0831.2010.00021.x

Given increasing political and financial commitments to wildfire preparedness, risk policy demands that risk identification, assessment, and mitigation activities are balanced among diverse resident groups.

Essential for this is the understanding of residents' perceptions of wildfire risks. This study compares wildfire-risk perceptions of Pennsylvania residents with those of Minnesotans living in natural-amenity-rich communities. Natural-amenity-driven migration shifts land-use patterns and social conditions, making it important to understand if and how such changes affect residents' perceptions of wildfire. Key informant interviews suggest land use and contrasting values associated with sociodemographic shifts were intertwined with wildfire-risk awareness, concern, and mitigation. In both study areas, local social interactions were impaired by geospatial and sociocultural barriers related to land use and population change. Barriers included perceived threats to quality of life, conflicting needs for economic development, and homes built in isolated locations. As a result, residents did not agree on community-wide notions of wildfire risk and response. Further, residents' ideas about the potential for a wildfire disaster did not correspond to those of risk managers. Although some places were attempting to overcome these challenges, many informants said their communities were overwhelmed with the effects of change. Finding common notions of wildfire risk is critical precisely because resident participation is crucial to hazard management. In these localities, rural community development can facilitate capacities to address wildfire risk in the context of landscape and social change.

Gordon, J. S., Gruver, J. B., Flint, C. G., & Luloff, A. E. (2013). Perceptions of Wildfire and Landscape Change in the Kenai Peninsula, Alaska. *Environmental Management, 52*, 807-820 https://doi.org/10.1007/s00267-013-0127-4

Despite a broad literature addressing the human dimensions of wildfire, current approaches often compartmentalize results according to disciplinary boundaries. Further, relatively few studies have focused on the public's evolving perceptions of wildfire as communities change over time. This paper responds to these gaps by exploring perceptions of landscape dynamics and wildfire between 2003 and 2007 using a typological framework of intersecting ecological, social, and cultural processes. Designed as a restudy, and using key informant interviews, this research allowed us to observe risk perception as they are related to community challenges and opportunities in the Kenai Peninsula, Alaska. Risk perceptions were examined as an integral part of community and landscape change. Wildfire was a concern among informants in 2003 and remained a concern in 2007, although informants were less likely to discuss it as a major threat compared to the original study. Informants in the western part of the peninsula tended to express more concern about wildfire than their eastern counterparts largely due to their experiences with recent fires. Other important factors residents considered included changing forest fuels, the expanding wildland urban interface, and contrasting values of new residents. Underscoring the localized nature of risk perceptions, informants had difficulty describing the probability of a wildfire event in a geographical context broader than the community scale. This paper demonstrates how a holistic approach can help wildfire and natural resource professionals, community members, and other stakeholders understand the social and physical complexities influencing collective actions or inactions to address the threat of wildfire.

Larsen, L. N. D., Howe, P. D., Brunson, M., Yocom, L., McAvoy, D., Berry, E. H., & Smith, J. W. (2021). Risk Perceptions and Mitigation Behaviors of Residents Following a near-Miss Wildfire. *Landscape and Urban Planning, 207* https://doi.org/10.1016/j.landurbplan.2020.104005

Wildfires pose significant risks to populations living in the Wildland-Urban Interface (WUI). We examine the influence of WUI residents' risk perceptions as well as other cognitive constructs (guided by Protection Motivation Theory) likely to influence their decisions to take wildfire mitigation actions

before and shortly after a near-miss wildfire. We used a drop-off/pick up survey to compare preand post-fire risk perceptions and mitigation actions of residents living in close proximity to the 416 Fire in southwestern Colorado, USA. Our research was guided by the general question, does a near-miss wildfire influence residents' perceptions and self-reported fire risk mitigation behaviors? Specifically, we examined the cognitive appraisals and physical risk factors influencing residents' previous and planned mitigation actions both before and after the fire. Our findings show risk perceptions declined significantly after the fire while residents' intentions to take nine different fire risk mitigation actions increased. These results suggest near-miss fire events result in simultaneous "let-downs" and "wake-up calls" among affected residents. Near-miss wildfires present a unique opportunity for wildfire community preparedness, outreach, and engagement programs to capitalize on an increased willingness to take risk mitigation actions. However, these programs may face difficulties in communicating the continued threat of subsequent fire events.

Martin, I. M., Bender, H., & Raish, C. (2007). What Motivates Individuals to Protect Themselves from Risks: The Case of Wildland Fires. *Risk Analysis, 27*, 887-900 https://doi.org/10.1111/j.1539-6924.2007.00930.x

This research investigates the cognitive perceptual process that homeowners go through when faced with the decision to protect themselves from the risk of wildfires. This decision can be examined by looking at the interaction between the integrated protection motivation theory— transtheoretical model and different levels of homeowners' subjective knowledge related to wildfire risks. We investigated the role of motivation, decision stages of risk readiness, and subjective knowledge on the number of risk-mitigating actions undertaken by homeowners living in high-risk communities. The results indicate that homeowners who are in an early or precontemplative stage (both low and high subjective knowledge) as well as low knowledge contemplatives are motivated by their perceived degree of vulnerability to mitigate the risk. In contrast, high knowledge contemplatives' potential behavioral changes are more likely to be motivated by increasing their perceptions of the severity of the risk. Risk-mitigating behaviors undertaken by high knowledge action homeowners are influenced by their perceptions of risk severity, self-efficacy, and response efficacy. In contrast, the low knowledge action homeowners engage in risk reduction behaviors without the influence of any of the PMT variables; demonstrating their motivation to emulate others in their community. These results have implications for the type of information that should be used to effectively communicate risks in an effort to influence the diverse homeowner segments to engage in risk-reduction behaviors.

Noonan-Wright, E., & Seielstad, C. A. (2021). Patterns of Wildfire Risk in the United States from Systematic Operational Risk Assessments: How Risk Is Characterised by Land Managers. *International Journal of Wildland Fire* https://doi.org/10.1071/WF21020

Since the turn of the 21st century, the complexity and costs of wildfires have increased substantially. There is a need to evaluate entrenched fire management practices that encourage status quo decision making to suppress fires. Data stored in mandated reporting systems collected during wildfires may provide a perspective on fire management decision-making needed to change wildfire governance structures. The Relative Risk Assessment (RRA) resides within a federally mandated workflow process necessary for all longer duration federal wildfires since 2010. Land managers rate hazard, probability and values at risk as high, moderate or low throughout the course of an incident to define wildfire risk as a precursor to strategy. 5,087 published risk assessments were evaluated to provide a snapshot of the

how land managers characterize risk from every geographic area (GA) in the United States. Results suggest that most GAs have a tendency to select moderate relative risk; however, two unique regions warranted greater inspection. The Northwest utilizes high risk more than any other geographic area; and the Southwest opts for low risk. Following a mixed method explanatory research design, these GAs became the basis for exploring factors influencing high and low risk by coding qualitative text belonging to the RRA. Investigation of a 20% sample of wildfires from these regions provided finer specificity of the values at risk, hazard, and probability concerns emerging during wildfires. Results suggest that climate plays a pivotal role to lessen the impact of the fire environment in the Southwest and generally increases the severity of the fire environment in the Northwest. When risk is low, land managers exercised greater decision space by using a variety of strategies. High risk constrains decision space and managers opt for suppression strategies. Subsequently, the Southwest is poised to benefit from favorable climate to use more fire and there is mounting evidence that a patchwork of historical wild and prescribed fires are leading to greater decision space for the management of current wildfires by serving as barriers to fire spread. However, suppression strategies were the most common for both GAs suggesting challenges remain for the use of fire to achieve resource objectives.

Strahan, K., & Gilbert, J. (2021). The Wait and See Literature: A Rapid Systematic Review. *Fire-Switzerland, 4* https://doi.org/10.3390/fire4010004

Delaying protective action decision making in wildfire is inconsistent with fire authorities' advice and is associated with fatalities. A comprehensive understanding of why at-risk residents wait and see whether they will evacuate from a wildfire or remain to shelter or defend can better inform wildfire safety policy and practice. This systematic review reports the findings of 40 papers selected from 255 identified through a search of papers in Scopus, Science Direct and Google Scholar published between 1995 and December 2020 in English. This review establishes the extent of wait and see behaviour; grounds for concern for such behaviour; reasons protective action is delayed; the influence of information and warnings; relevance of gender and other characteristics; delay by those who defend their property; and policy implications. This review also details 11 seminal studies that capture much of the evidence on the delay of protective action in wildfire.

Risk Communication & Warnings

Cao, Y. H., Boruff, B. J., & McNeill, I. M. (2017). Towards Personalised Public Warnings: Harnessing Technological Advancements to Promote Better Individual Decision-Making in the Face of Disasters. *International Journal of Digital Earth, 10*, 1231-1252 https://doi.org/10.1080/17538947.2017.1302007

Official warnings are essential for informing the public of impending hazards and promoting their responses before a disaster occurs. However, research has identified that traditional public warnings, such as generic text messages based on large geographic regions, often fail to promote appropriate responses by at-risk residents. Recently, there has been an increased focus on using map-based approaches for communicating public warnings. However, a systematic framework to guide the design of effective mapping instruments for this purpose is lacking. The researchers sought to fill this gap by merging the scholarly understanding of factors influencing warning effectiveness with the contemporary spatial capacities of the emergency management sector. The current paper presents the conceptual framework resulting from this merger, which can be used to direct the design and implementation of

map-based warnings that offer personalised risk visualisation and provide personalised decision support to motivate appropriate responses. An example is then provided to illustrate how this framework can be applied for the development of personalised bushfire warnings in an Australian context. Underpinned by webGIS technologies, the proposed framework shows a potentially ground-breaking approach to improve public warning communication by fostering more efficient and effective risk personalisation and response related decision-making by individuals.

Colavito, M., Wolfson, B. S., Thode, A. E., Haffey, C., & Kimball, C. (2020). Integrating Art and Science to Communicate the Social and Ecological Complexities of Wildfire and Climate Change in Arizona, USA. *Fire Ecology, 16* https://doi.org/10.1186/s42408-020-00078-w

Background This paper describes Fires of Change, a collaborative art exhibit designed to communicate about the shifting fire regimes of the United States Southwest through the lens of multimedia art. The Southwest Fire Science Consortium and Landscape Conservation Initiative, both of which are boundary organizations that facilitate collaboration among managers and scientists to develop and apply actionable science, organized Fires of Change by convening scientists, managers, and artists in the co-production of science-based artwork. Surveys were conducted with Fires of Change exhibit visitors to assess the impacts of viewing the exhibit, as well as with exhibit creators to assess the effects of participating in the project. Results The visitor survey results demonstrate that Fires of Change exhibits increased visitors' understanding of the effect of climate change on fire regimes and increased visitors' support for management actions to address the effects of climate change on fire behavior. The exhibit creator survey results demonstrate that the development of Fires of Change created new relationships and networks among the participants and increased appreciation for collaborations among scientists, managers, and artists. Specifically, science-management relationships, networks, and boundary organizations may have facilitated the project. Conclusions Fires of Change demonstrates that art can be an effective mechanism for communicating about complex ecological issues and that, by collaborating in the development of artwork, scientists and managers can create new partnerships.

Cova, T. J., Dennison, P. E., Li, D. P., Drews, F. A., Siebeneck, L. K., & Lindell, M. K. (2017). Warning Triggers in Environmental Hazards: Who Should Be Warned to Do What and When? *Risk Analysis, 37*, 601-611 https://doi.org/10.1111/risa.12651

Determining the most effective public warnings to issue during a hazardous environmental event is a complex problem. Three primary questions need to be answered: Who should take protective action? What is the best action? and When should this action be initiated? Warning triggers provide a proactive means for emergency managers to simultaneously answer these questions by recommending that a target group take a specified protective action if a preset environmental trigger condition occurs (e.g., warn a community to evacuate if a wildfire crosses a proximal ridgeline). Triggers are used to warn the public across a wide variety of environmental hazards, and an improved understanding of their nature and role promises to: (1) advance protective action theory by unifying the natural, built, and social themes in hazards research into one framework, (2) reveal important information about emergency managers' risk perception, situational awareness, and threat assessment regarding threat behavior and public response, and (3) advance spatiotemporal models for representing the geography and timing of disaster warning and response (i.e., a coupled natural-built-social system). We provide an overview and research agenda designed to advance our understanding and modeling of warning triggers.

Dixon, G., Bullock, O., & Adams, D. (2019). Unintended Effects of Emphasizing the Role of Climate Change in Recent Natural Disasters. *Environmental Communication-a Journal of Nature and Culture, 13*(2), 135-143 https://doi.org/10.1080/17524032.2018.1546202

In 2017, the United States experienced a series of natural hazards (hurricanes, wildfires, and blizzards) that resulted in significant loss of life and property. Emphasizing the role of climate change in these events might offer an important tool for engagement, particularly with skeptical audiences. However, in a survey experiment (N = 1504) involving three different natural hazards - hurricanes, wildfires, and blizzards - we find that emphasizing the role of climate change in these hazards produced unintended effects for climate change skeptics. In particular, skeptics experienced resistance to the news article, which associated with reduced perceived hazard severity. These backfiring effects likely serve as a defensive mechanism used by skeptics to maintain their prior views of climate change, illustrating the challenges faced in communicating climate change to skeptical audiences. These findings offer additional insight for those attempting to communicate climate-related risk information to skeptical audiences.

Doermann, J. L. (2019). *Development of a Research- Based Short Message Creation Tool for Wildfire Emergencies.* University of Maryland, null database. https://doi.org/10.13016/ffno-i0fl

Wireless Emergency Alerts are short message alerts that authorities can send to devices in specific geographical regions during times of imminent threat. These messages give authorities the ability to distribute important information in a timely manner to those who need it most. The majority of research regarding best practices for creating short message alerts is vague and requires interpretation before implementation. This thesis reviews and analyzes research and evidence-based guidance currently available to those creating short message alerts. Using the research, evidence-based guidance, and subsequent analysis, fifteen user prompts were developed and implemented to build a message creation tool that generates wildfire evacuation messages. The result of using the tool is a wildfire-based evacuation message that auto-incorporates the research and guidance currently available. This thesis helps develop a foundation for the bridge between short message alert research and the practical generation of messages during imminent threat emergencies.

Doermann, J. L., Kuligowski, E. D., & Milke, J. (2021). From Social Science Research to Engineering Practice: Development of a Short Message Creation Tool for Wildfire Emergencies. *Fire Technology, 57*, 815-837 https://doi.org/10.1007/s10694-020-01008-7

During imminent threat emergencies, an authorities' ability to communicate with the public and provide them with timely and accurate information is imperative. Wireless emergency alerts (WEAs) sent via the integrated public alert and warning system are short message alerts that authorities can send to devices in specific geographical regions during times of imminent threat. These messages give authorities the ability to distribute important information in a timely manner to those who need it most. In September 2016, the Federal Communications Commission adopted rules to strengthen the WEA system, including increasing the character limit of WEAs from 90c. to 360c. for 4G LTE and newer devices. Implemented in December 2019, the additional 270c. provide authorities with an opportunity to share supplemental and clarifying information in WEA messages. Current research regarding best practices for creating short message alerts was reviewed and analyzed to develop evidence-based guidance, and in turn, create a tool that, with only fifteen user-prompts, can be used to rapidly create effective and informative wildfire

evacuation messages of up to 360c. A message creator can use this tool by selecting or entering responses to each of the fifteen prompts. This article presents a bridge between social science research on short message alert effectiveness and the practical generation of messages during imminent threat emergencies. Future research is proposed to develop this tool for purposes other than evacuation, for hazards other than wildfires, and for systems other than WEA (e.g., mass notification systems).

Eriksen, C., & Prior, T. (2011). The Art of Learning: Wildfire, Amenity Migration and Local Environmental Knowledge. *International Journal of Wildland Fire, 20*(4), 612-624 https://doi.org/10.1071/WF10018

Communicating the need to prepare well in advance of the wildfire season is a strategic priority for wildfire management agencies worldwide. However, there is considerable evidence to suggest that although these agencies invest significant effort towards this objective in the lead up to each wildfire season, landholders in at-risk locations often remain under-prepared. One reason for the poor translation of risk information materials into actual preparation may be attributed to the diversity of people now inhabiting wildfire-prone locations in peri-urban landscapes. These people hold widely varying experiences, beliefs, attitudes and values relating to wildfire, which influence their understanding and interpretation of risk messages - doing so within the constraints of their individual contexts. This paper examines the diversity of types of local environmental knowledge (LEK) present within wildfire-prone landscapes affected by amenity-led in-migration in south-east Australia. It investigates the ways people learn and form LEK of wildfire, and how this affects the ability of at-risk individuals to interpret and act on risk communication messages. We propose a practical framework that complements existing risk education mechanisms with engagement and interaction techniques (agency-community and within community) that can utilise LEK most effectively and facilitate improved community-wide learning about wildfire and wildfire preparedness.

Jolly, W. M., & Freeborn, P. H. (2017). Towards Improving Wildland Firefighter Situational Awareness through Daily Fire Behaviour Risk Assessments in the Us Northern Rockies and Northern Great Basin. *International Journal of Wildland Fire, 26*, 574-586 https://doi.org/10.1071/WF16153

Wildland firefighters must assess potential fire behaviour in order to develop appropriate strategies and tactics that will safely meet objectives. Fire danger indices integrate surface weather conditions to quantify potential variations in fire spread rates and intensities and therefore should closely relate to observed fire behaviour. These indices could better inform fire management decisions if they were linked directly to observed fire behaviour. Here, we present a simple framework for relating fire danger indices to observed categorical wildland fire behaviour. Ordinal logistic regressions are used to model the probabilities of five distinct fire behaviour categories that are then combined with a safety-based weight function to calculate a Fire Behaviour Risk rating that can plotted over time and spatially mapped. We demonstrate its development and use across three adjacent US National Forests. Finally, we compare predicted fire behaviour risk ratings with observed variations in satellite-measured fire radiative power and we link these models with spatial fire danger maps to demonstrate the utility of this approach for landscape-scale fire behaviour risk assessment. This approach transforms fire weather conditions into simple and actionable fire behaviour risk metrics that wildland firefighters can use to support decisions that meet required objectives and keep people safe.

Matlock, T., Coe, C., & Westerling, A. L. (2017). Monster Wildfires and Metaphor in Risk Communication. *Metaphor and Symbol, 32*, 250-261 https://doi.org/10.1080/10926488.2017.1384273

This work examines the use and understanding of metaphor in wildfire discourse. We focus on the framing of wildfires as monsters, seen in statements such as "*Monster wildfire rages in Colorado*" and "*Two monster wildfires in Northern California are slowly being tamed*", which reflect a "*WILDFIRE IS MONSTER*" metaphor. Study 1 analyzes how and when this phrase is used in TV news reports of wildfires, and Study 2A and Study 2B investigate how it influences reasoning about risks associated with wildfire. The results show that metaphor is widely used in framing news reports about significant wildfires, and that its use influences how people reason about them. The work is part of a project aimed at developing better ways to communicate about risks related to natural events and climate change.

Monroe, M. C., Long, A. J., & Marynowski, S. (2003). Wildland Fire in the Southeast - Negotiating Guidelines for Defensible Space. *Journal of Forestry, 101*, 14-19 https://doi.org/10.1093/jof/101.3.14

Wildland fire is becoming a concern for residents in many eastern states as fuel loads, weather patterns, and population growth increase risk at the wildland-urban interface. Some messages about reducing risk, however, are based on western wildfire information and are seen as inappropriate by wildland fire communicators in Florida. This case study describes the process of reaching agreement on landscape modifications that reduce the risk of wildland fire for interface residents in the Southeast. The melding of various perspectives through a negotiated process helped create a product that meets a need in this fire-prone state.

National Research Council. (2013). *Public Response to Alerts and Warnings Using Social Media: Report of a Workshop on Current Knowledge and Research Gaps.* The National Academies Press Washington, DC. https://doi.org/10.17226/15853

Following an earlier NRC workshop on public response to alerts and warnings delivered to mobile devices, a related workshop was held on February 28 and 29, 2012 to look at the role of social media in disaster response. This was one of the first workshops convened to look systematically at the use of social media for alerts and warnings—an event that brought together social science researchers, technologists, emergency management professionals, and other experts on how the public and emergency managers use social media in disasters. In addition to exploring how officials monitor social media, as well as the resulting privacy considerations, the workshop focused on such topics as: what is known about how the public responds to alerts and warnings; the implications of what is known about such public responses for the use of social media to provide alerts and warnings to the public; and approaches to enhancing the situational awareness of emergency managers. Public Response to Alerts and Warnings Using Social Media: Report of a Workshop on Current Knowledge and Research Gaps summarizes presentations made by invited speakers, other remarks by workshop participants, and discussions during parallel breakout sessions. It also points to potential topics for future research, as well as possible areas for future research investment, and it describes some of the challenges facing disaster managers who are seeking to incorporate social media into regular practice.

Olsen, C. S., Mazzotta, D. K., Toman, E., & Fischer, A. P. (2014). Communicating About Smoke from Wildland Fire: Challenges and Opportunities for Managers. *Environmental Management, 54*, 571-582 https://doi.org/10.1007/s00267-014-0312-0

Wildland fire and associated management efforts are dominant topics in natural resource fields. Smoke from fires can be a nuisance and pose serious health risks and aggravate pre-existing health conditions. When it results in reduced visibility near roadways, smoke can also pose hazardous driving conditions and reduce the scenic value of vistas. Communicating about smoke, whether in the preparation phases before a planned burn or during a wildfire event, can enable those at risk to make informed decisions to minimize their exposure to smoke or choose alternate activities that mitigate smoke completely. To date, very little research has been completed on the social aspects of smoke, such as communication or public perceptions. Here, we present findings from an exploratory study that examined challenges and opportunities related to communication (within agencies or to the public) for management of smoke from wildland fires. Interviews were conducted in California, Oregon, Montana, and South Carolina among a purposive sample of individuals, who are involved in fire or smoke management. Findings indicate that smoke poses several challenges to management agencies. Findings also provide insight into potential strategies to address such challenges by improving communication in both inter- and intra-agency situations as well as with members of the public. In particular, prioritizing fire and smoke-related communication within agencies, allocating agency resources specifically for training in communication and outreach endeavors, taking advantage of existing resources including informal social networks among the public, and building long-term relationships both between agencies and with the public were viewed as effective.

Paveglio, T., Carroll, M. S., Absher, J. D., & Norton, T. (2009). Just Blowing Smoke? Residents' Social Construction of Communication About Wildfire. *Environmental Communication-a Journal of Nature and Culture, 3*, 76-94 https://doi.org/10.1080/17524030802704971

This study uses social constructionism as a basis for understanding the effectiveness of communication about wildfire risk between agency officials and wildland-urban interface (WUI) residents. Risk communication literature demonstrates a well-documented difference in the way land managers and stakeholders conceptualize risk. This is especially true of fire because management of these hazards have changed so drastically in past decades; fire managers have typically struggled to clearly articulate the current management policy to the public or integrate their specific knowledge in the risk management process. This study contributes to an understanding of how WUI residents construct communication about wildland fire and agency effectiveness in communicating the new era of fire inclusion. Specifically, we explore the personal and professional sources of information residents' use to understand their fire risk and the subjects they would like more information about. We also explore the continued viability of Smokey Bear, the most enduring symbol of fire management.

Steelman, T. A., & McCaffrey, S. (2013). Best Practices in Risk and Crisis Communication: Implications for Natural Hazards Management. *Natural Hazards, 65*, 683-705 https://doi.org/10.1007/s11069-012-0386-z

As societies evolve, often the most appropriate response to the hazard must also evolve. However, such shifts in appropriate response to a hazard, whether at the individual or at the societal level, are rarely straightforward: Closing the gap between desired practice and current practice requires effective

communication. Although there is a significant literature on how to encourage adaptation before an event and how to communicate during an event, there is less work tying the two together or on how to communicate shifts in larger scale societal response to a natural hazard. In this article, we bring together the best practices and theoretical literature from risk communication and crisis communication and empirical literature on wildfire communication to derive the key characteristics associated with best communication practices. We then use this framework on three case studies of wildfires in California, Montana, and Wyoming, each of which used a different strategy for managing the fire, to understand whether approaching communication more holistically can lead to more desired natural hazard management outcomes. Our working hypothesis was as follows: effective communication before and during a fire would be associated with acceptance of more flexible fire management strategies. The findings indicate how a type of desired management change (more flexible fire management) is associated with more effective communication practices before and during the event.

Sutton, J., Spiro, E. S., Johnson, B., Fitzhugh, S., Gibson, B., & Butts, C. T. (2014). Warning Tweets: Serial Transmission of Messages During the Warning Phase of a Disaster Event. *Information Communication & Society, 17*, 765-787 https://doi.org/10.1080/1369118X.2013.862561

Serial transmission - the passing on of information from one source to another - is a phenomenon of central interest in the study of informal communication in emergency settings. Microblogging services such as Twitter make it possible to study serial transmission on a large scale and to examine the factors that make retransmission of messages more or less likely. Here, we consider factors predicting serial transmission at the interface of formal and informal communication during disaster; specifically, we examine the retransmission by individuals of messages (tweets) issued by formal organizations on Twitter. Our central question is the following: How do message content, message style, and public attention to tweets relate to the behavioral activity of retransmitting (i.e. retweeting) a message in disaster? To answer this question, we collect all public tweets sent by a set of official government accounts during a 48-hour period of the Waldo Canyon wildfire. We manually code tweets for their thematic content and elements of message style. We then create predictive models to show how thematic content, message style, and changes in number of Followers affect retweeting behavior. From these predictive models, we identify the key elements that affect public retransmission of messages during the emergency phase of an unfolding disaster. Our findings suggest strategies for designing and disseminating messages through networked social media under periods of imminent threat.

Taylor, J. G., Gillette, S. C., Hodgson, R. W., Downing, J. L., Burns, M. R., Chavez, D. J., & Hogan, J. T. (2007). Informing the Network: Improving Communication with Interface Communities During Wildland Fire. *Human Ecology Review, 14*(2), 198-211 Retrieved from https://www.fs.usda.gov/treesearch/pubs/37028

An interagency research team studied fire communications that took place during different stages of two wildfires in southern California: one small fire of short duration and one large fire of long duration. This "quick- response" research showed that pre-fire communication planning was particularly effective for smaller fire events and parts of that planning proved invaluable for the large fire event as well. Information seeking by the affected public relied on locally convenient sources during the small fire. During the large fire, widespread evacuations disrupted many of the local informal communication networks. Residents' needs were for "real-time," place-specific information: precise location, severity, size, and direction of spread of the fires. Fire management agencies must contribute real-time, place-

specific fire information when it is most needed by the affected public, as they try to make sense out of the chaos of a wildland fire. Disseminating fire information as broadly as possible through multiple pathways will maximize the probability of the public finding the information they need.

Velez, A.-L. K., Diaz, J. M., & Wall, T. U. (2017). Public Information Seeking, Place-Based Risk Messaging and Wildfire Preparedness in Southern California. *International Journal of Wildland Fire, 26*(6), 469-477 https://doi.org/https://doi.org/10.1071/WF16219

Southern California is a challenging environment for managing and adapting to wildland–urban interface fires. Previous research shows risk perception and information seeking are related and that public information dissemination influences locally specific risk perception and preparedness actions. Here, we examine relationships between residents' wildfire knowledge and experience, readiness actions and media choice to determine how to integrate preparedness information and the recently developed Santa Ana Wildfire Threat Index into public information. Based on frequencies, means tests and correlations, we find television most frequently used for both daily news and wildfire information and that most people intend to seek information from the same sources in future fires. Wildfire knowledge, experience and past preparedness actions influence the number of sources from which respondents report seeking information. We note significant geographic differences in information sources used before and during wildfire, with higher percentages of residents in more rural areas relying on television, radio, Reverse 911, and friends and family for information during a wildfire. Findings support previous research results indicating sources considered trustworthy are not always considered the most up-to-date. Our findings support other empirical research recommending a multimedia, two-way communication model for event-based and readiness information supplemented with one-way sources like television.

Weyrich, P., Ruin, I., Terti, G., & Scolobig, A. (2021). Using Serious Games to Evaluate the Potential of Social Media Information in Early Warning Disaster Management. *International Journal of Disaster Risk Reduction, 56* https://doi.org/10.1016/j.ijdrr.2021.102053

In recent years, the sharp increase in the use of social media by the public during major natural disasters has attracted the attention of various public agencies and safety organizations. Social media present a potential alternative communication system not only for disseminating information to the public, but also for receiving information from the individuals at risk. However, there is limited research on how emergency managers would use such information and whether it would make warning decision-making more effective or not. To address this gap, we used an existing serious game to accommodate informational and communication complexities in early warning disaster management. We played 4 game sessions with practitioners and PhD students involved in disaster risk management to simulate and test how public information from social media is used in emergency operation centres to make (protective and communicative) decisions. This includes how information is perceived in terms of levels of trust, usefulness and completeness depending on its type, source, quality/content and channel. Overall, we observe that information from the crowd disseminated on social media leads to better decisions and increases associated confidence levels. More precisely, we find that information from weather spotters, i.e. people trained in meteorology, is more trusted than information from the general public independent of the information quality. Ultimately, we demonstrate the usefulness of public social media information in warning decision-making, as well as the potential of serious games to

evaluate warning communication, for instance by increasing warning communication literacy and enhancing collaborative capacity.

Decision Support & Incident Management

Bayham, J., Belval, E. J., Thompson, M. P., Dunn, C., Stonesifer, C. S., & Calkin, D. E. (2020). Weather, Risk, and Resource Orders on Large Wildland Fires in the Western Us. *Forests, 11*(2), 169 https://doi.org/10.3390/f11020169

Research Highlights: Our results suggest that weather is a primary driver of resource orders over the course of extended attack efforts on large fires. Incident Management Teams (IMTs) synthesize information about weather, fuels, and order resources based on expected fire growth rather than simply reacting to observed fire growth. Background and Objectives: Weather conditions are a well-known determinant of fire behavior and are likely to become more erratic under climate change. Yet, there is little empirical evidence demonstrating how IMTs respond to observed or expected weather conditions. An understanding of weather-driven resource ordering patterns may aid in resource prepositioning as well as forecasting suppression costs. Our primary objective is to understand how changing weather conditions influence resource ordering patterns. Our secondary objective is to test how an additional risk factor, evacuation, as well as a constructed risk metric combining fire growth and evacuation, influences resource ordering. Materials and Methods: We compile a novel dataset on over 1100 wildfires in the western US from 2007-2013, integrating data on resource requests, detailed weather conditions, fuel and landscape characteristics, values at risk, fire behavior, and IMT expectations about future fire behavior and values at risk. We develop a two-step regression framework to investigate the extent to which IMTs respond to realized or expected weather-driven fire behavior and risks. Results: We find that IMTs' expectations about future fire growth are influenced by observed weather and that these expectations influence resource ordering patterns. IMTs order nearly twice as many resources when weather conditions are expected to drive growth events in the near future. However, we find little evidence that our other risk metrics influence resource ordering behavior (all else being equal). Conclusion: Our analysis shows that incident management teams are generally forward-looking and respond to expected rather than recently observed weather-driven fire behavior. These results may have important implications for forecasting resource needs and costs in a changing climate.

Calkin, D. E., Cohen, J. D., Finney, M. A., & Thompson, M. P. (2014). How Risk Management Can Prevent Future Wildfire Disasters in the Wildland-Urban Interface. *Proceedings of the National Academy of Sciences of the United States of America, 111*, 746-751 https://doi.org/10.1073/pnas.1315088111

Recent fire seasons in the western United States are some of the most damaging and costly on record. Wildfires in the wildland-urban interface on the Colorado Front Range, resulting in thousands of homes burned and civilian fatalities, although devastating, are not without historical reference. These fires are consistent with the characteristics of large, damaging, interface fires that threaten communities across much of the western United States. Wildfires are inevitable, but the destruction of homes, ecosystems, and lives is not. We propose the principles of risk analysis to provide land management agencies, first responders, and affected communities who face the inevitability of wildfires the ability to reduce the potential for loss. Overcoming perceptions of wildland-urban interface fire disasters as a wildfire control problem rather than a home ignition problem, determined by home ignition conditions, will reduce home loss.

Canton-Thompson, J., Gebert, K. M., Thompson, B., Jones, G., Calkin, D., & Donovan, G. (2008). External Human Factors in Incident Management Team Decision-making and Their Effect on Large Fire Suppression Expenditures. *Journal of Forestry, 106*(8), 416-424 Retrieved from https://www.fs.usda.gov/treesearch/pubs/32023

Large wildland fires are complex, costly events influenced by a vast array of physical, climatic, and social factors. Changing climate, fuel buildup due to post suppression, and increasing populations in the wildland-urban interface have all been blamed for the extreme fire seasons and rising suppression expenditures of recent years. With each high-cost year comes a multitude of fire cost reviews, suppression cost studies by federal oversight agencies, and new rules and regulations focused on containing or reducing suppression costs. However, largely ignored in many of these inquiries are the human factors and pressures outside (external to) the influence of the incident team managing a fire that are contributing to the problem. This article presents an in-depth examination of some external human factors that affect incident management team (IMT) decision-making and influence suppression costs. Data were collected during 2004 and 2005 through 48 in-depth interviews with IMT command and general staff members representative of each Geographic Area Coordination Center, a I federal agencies, and many state agencies whose employees serve on teams. External human factors identified include risk management; interaction with agency administrators; policies, regulations, and rules; resource availability; and social-political pressure. Inattention to these factors can result in policies that adversely affect IMTs charged with managing highly volatile events in a safe, timely, and cost-efficient manner.

Colavito, M. M. (2017). Utilising Scientific Information to Support Resilient Forest and Fire Management. *International Journal of Wildland Fire, 26*(5), 375-383 https://doi.org/10.1071/WF16158

There is increasing interest in better understanding resilience in forest and fire management but a great deal of uncertainty about the characteristics of resilient systems. This presents an opportunity for scientists, managers and other constituents to work together to develop actionable scientific information to inform planning, decision-making and implementation that fosters resilience in forest and fire management. However, despite efforts to improve the usability of scientific information, effectively connecting science and decision-making remains a challenge. Following a workshop about ecosystem resilience in the Southwest United States, interviews were conducted with scientists, managers and other constituents to assess the use of scientific information in forest and fire management. Interview respondents were asked how scientific information is used in management, how management needs are considered in research, how scientific information is communicated, what scientific information is lacking and how scientists and managers can most effectively work together. The results provide insight into the application, development and communication of scientific information, resilience research needs and recommendations for facilitating collaborative research. In-person interactions, identification of common goals, and sustained, ongoing communication are identified as the most important strategies for facilitating collaboration among scientists, managers and other constituents to support resilient forest and fire management.

Colavito, M. (2021). The Human Dimensions of Spatial, Pre-Wildfire Planning Decision Support Systems: A Review of Barriers, Facilitators, and Recommendations. *Forests, 12*(4), 483 https://doi.org/10.3390/f12040483

Decision support systems (DSSs) are increasingly common in forest and wildfire planning and management in the United States. Recent policy direction and frameworks call for collaborative assessment of wildfire risk to inform fuels treatment prioritization using the best available science. There are numerous DSSs applicable to forest and wildfire planning, which can support timely and relevant information for decision making, but the use and adoption of these systems is inconsistent. There is a need to elucidate the use of DSSs, specifically those that support pre-wildfire, spatial planning, such as wildfire risk assessment and forest fuels treatment prioritization. It is important to understand what DSSs are in use, barriers and facilitators to their use, and recommendations for improving their use. Semi-structured interviews with key informants were used to assess these questions. Respondents identified numerous barriers, as well as recommendations for improving DSS development and integration, specifically with respect to capacity, communication, implementation, question identification, testing, education and training, and policy, guidance, and authorities. These recommendations can inform DSS use for wildfire risk assessment and treatment prioritization to meet the goals of national policies and frameworks. Lastly, a framework for organizing spatial, pre-wildfire planning DSSs to support end-user understanding and use is provided.

Colavito, M. M., Trainor, S. F., Kettle, N. P., & York, A. (2019). Making the Transition from Science Delivery to Knowledge Coproduction in Boundary Spanning: A Case Study of the Alaska Fire Science Consortium. *Weather Climate and Society, 11*, 917-934 https://doi.org/10.1175/WCAS-D-19-0009.1

Boundary organizations facilitate two-way, sustained interaction and communication between research and practitioner spheres, deliver existing science, and develop new, actionable scientific information to address emerging social-ecological questions applicable to decision-making. There is an increasing emphasis on the role of boundary organizations in facilitating knowledge coproduction, which is collaborative research with end users to develop actionable scientific information for decision-making. However, a deeper understanding of how boundary organizations and knowledge coproduction work in practice is needed. This paper examines the Alaska Fire Science Consortium (AFSC), a boundary organization focused on fire science and management in Alaska that is working to address climate impacts on wildfire. A case study approach was used to assess AFSC activities over time. AFSC's boundary spanning involves a continuum of outputs and activities, but their overall trajectory has involved a deliberate transition from an emphasis on science delivery to knowledge coproduction. Key factors that facilitated this transition included a receptive and engaged audience, built-in evaluation and learning, subject matter expertise and complementarity, and embeddedness in the target audience communities. Recommendations for boundary organizations wishing to develop knowledge coproduction capacity include knowing your audience, employing trusted experts in boundary spanning, and engaging in frequent self-evaluation to inform change over time.

Dunn, C. J., Calkin, D. E., & Thompson, M. P. (2017). Towards Enhanced Risk Management: Planning, Decision Making and Monitoring of Us Wildfire Response. *International Journal of Wildland Fire, 26*, 551-556 https://doi.org/10.1071/WF17089

Wildfire's economic, ecological and social impacts are on the rise, fostering the realisation that business-as-usual fire management in the United States is not sustainable. Current response strategies may be inefficient and contributing to unnecessary responder exposure to hazardous conditions, but significant knowledge gaps constrain clear and comprehensive descriptions of how changes in response strategies and tactics may improve outcomes. As such, we convened a special session at an international wildfire conference to synthesise ongoing research focused on obtaining a better understanding of wildfire response decisions and actions. This special issue provides a collection of research that builds on those discussions. Four papers focus on strategic planning and decision making, three papers on use and effectiveness of suppression resources and two papers on allocation and movement of suppression resources. Here we summarise some of the key findings from these papers in the context of risk-informed decision making. This collection illustrates the value of a risk management framework for improving wildfire response safety and effectiveness, for enhancing fire management decision making and for ushering in a new fire management paradigm.

Fischer, A. P., & Charnley, S. (2012). Risk and Cooperation: Managing Hazardous Fuel in Mixed Ownership Landscapes. *Environmental Management, 49*, 1192-1207 https://doi.org/10.1007/s00267-012-9848-z

Managing natural processes at the landscape scale to promote forest health is important, especially in the case of wildfire, where the ability of a landowner to protect his or her individual parcel is constrained by conditions on neighboring ownerships. However, management at a landscape scale is also challenging because it requires cooperation on plans and actions that cross ownership boundaries. Cooperation depends on people's beliefs and norms about reciprocity and perceptions of the risks and benefits of interacting with others. Using logistic regression tests on mail survey data and qualitative analysis of interviews with landowners, we examined the relationship between perceived wildfire risk and cooperation in the management of hazardous fuel by nonindustrial private forest (NIPF) owners in fire-prone landscapes of eastern Oregon. We found that NIPF owners who perceived a risk of wildfire to their properties, and perceived that conditions on nearby public forestlands contributed to this risk, were more likely to have cooperated with public agencies in the past to reduce fire risk than owners who did not perceive a risk of wildfire to their properties. Wildfire risk perception was not associated with past cooperation among NIPF owners. The greater social barriers to private-private cooperation than to private-public cooperation, and perceptions of more hazardous conditions on public compared with private forestlands may explain this difference. Owners expressed a strong willingness to cooperate with others in future cross-boundary efforts to reduce fire risk, however. We explore barriers to cooperative forest management across ownerships, and identify models of cooperation that hold potential for future collective action to reduce wildfire risk.

Grayzeck-Souter, S. A., Nelson, K. C., Brummel, R. F., Jakes, P., & Williams, D. R. (2009). Interpreting Federal Policy at the Local Level: The Wildland-Urban Interface Concept in Wildfire Protection Planning in the Eastern United States. *International Journal of Wildland Fire, 18*, 278-289 https://doi.org/10.1071/WF08081

In 2003, the Healthy Forests Restoration Act (HFRA) called for USA communities at risk of wildfire to develop Community Wildfire Protection Plans (CWPPs) requiring local, state and federal actors to work

together to address hazardous fuels reduction and mitigation efforts. CWPPs can provide the opportunity for local government to influence actions on adjacent public land, by establishing local boundaries of the wildland-urban interface (WUI), the area where urban lands meet or intermix with wildlands. The present paper explores local response to the HFRA and CWPPs in the eastern USA, specifically if and how communities are using the policy incentive to identify the WUI. We conducted document reviews of eastern CWPPs, as well as qualitative analysis of in-depth interviews with participants in four case studies. We found tremendous variation in local response to HFRA, with plans completed at multiple scales and using different planning templates. The WUI policy incentive was not used in all CWPPs, suggesting that the incentive is not as useful in the eastern USA, where public land is less dominant and the perceived fire risk is lower than in the West. Even so, many communities in the East completed CWPPs to improve their wildfire preparedness.

Hunter, M. E., Colavito, M. M., & Wright, V. (2020). The Use of Science in Wildland Fire Management: A Review of Barriers and Facilitators. *Current Forestry Reports, 6*, 354-367 https://doi.org/10.1007/s40725-020-00127-2

Purpose of Review Science plays a critical role in natural resource management, and the use of science in decision-making is mandated by several policy initiatives. Other disciplines have documented the challenges associated with applying science to management and possible solutions to overcoming challenges, but the evaluation of science use in wildland fire management is relatively immature. In this paper, we reviewed the available literature that evaluates science use in wildland fire management and common barriers and facilitators to science use in decision-making. Recent Findings We developed a conceptual model that describes the possible uses of science in fire management (perception, planning, forecasting, implementation, assessment, communication, and policy), common barriers to science use (lack of science, uncertainty, funding/capacity, conflict), common facilitators to fire science use (collaboration, trust, boundary organizations, co-production), and factors that can act as facilitators or barriers to science use depending on their presence or absence (awareness, accessibility, relevance). In the context of our conceptual model, we reviewed 67 papers that examined fire science use between 1986 and 2019. Most studies were conducted in the USA in the last 10 years and demonstrated that science is commonly used in fire management and that the maturation of organizations devoted to science translation and communication in the last 10 years has likely facilitated the application of fire science. The evaluation of fire science use, however, is still relatively immature, with studies needed on the use of fire science in countries outside the USA, the use of science in the management of wildfires, and in the crafting of policy related to wildland fire management.

Mahmoud, H., & Chulahwat, A. (2020). Assessing Wildland-Urban Interface Fire Risk. *Royal Society Open Science, 7* https://doi.org/10.1098/rsos.201183

Recent wildfire events, in the United States (USA) and around the world, have resulted in thousands of homes destroyed and many lives lost, leaving communities and policy makers, once again, with the question as to how to manage wildfire risk. This is particularly important given the prevalent trend of increased fire frequency and intensity. Current approaches to managing wildfires focus on fire suppression and managing fuel build-up in wildlands. However, reliance on these strategies alone has clearly proven inadequate. As such, focus should be shifted towards minimizing potential losses to communities. Achieving this goal, however, requires detailed understanding of the factors that contribute to community vulnerability and the interplay between probability of ignition, vulnerability

and calculated risk. In this study, we evaluate wildfire risk for four different communities across the USA for the duration of May to September to communicate a different perspective of risk assessment. We show, for the first time, that community risk is closely related to wind speed and direction, pattern of surrounding wildland vegetation, and buildings layout. The importance of the findings lies in the need for exploring unique viable solutions to reduce risk for every community independently as opposed to embracing a generalized approach as is currently the case.

McLennan, J., Holgate, A. M., Omodei, M. M., & Wearing, A. J. (2006). Decision Making Effectiveness in Wildfire Incident Management Teams. *Journal of Contingencies & Crisis Management, 14*, 27-37 https://doi.org/10.1111/j.1468-5973.2006.00478.x

During large scale wildfires, suppression activities are carried out under the direction of an Incident Management Team (IMT). The aim of the research was to increase understanding of decision processes potentially related to IMT effectiveness. An IMT comprises four major functions: Command, Operations, Planning, and Logistics. Four methodologies were used to study IMT processes: computer simulation experiments; analyses of wildfire reports; interviews with IMT members; and cognitive ethnographic studies of IMTs. Three processes were important determinants of IMT effectiveness: information management and cognitive overload; matching component function goals to overall goals; and team metacognition to detect and counter task-disruptive developments. These processes appear to be complex multi-person analogues of individual Incident Command processes identified previously. The findings have implications for issues such as: creating IMTs; training IMTs; managing IMTs; and providing decision support to IMTs.

O'Connor, C. D., Thompson, M. P., & Rodríguez y Silva, F. (2016). Getting Ahead of the Wildfire Problem: Quantifying and Mapping Management Challenges and Opportunities. *Geosciences, 6* https://doi.org/10.3390/geosciences6030035

Wildfire is a global phenomenon that plays a vital role in regulating and maintaining many natural and human-influenced ecosystems but that also poses considerable risks to human populations and infrastructure. Fire managers are charged with balancing the short-term protection of human assets sensitive to fire exposure against the potential long-term benefits that wildfires can provide to natural systems and wildlife populations. The compressed decision timeframes imposed on fire managers during an incident are often insufficient to fully assess a range of fire management options and their respective implications for public and fire responder safety, attainment of land and resource objectives, and future trajectories of hazard and risk. This paper reviews the role of GIS-based assessment and planning to support operational wildfire management decisions, with a focus on recent and emerging research that pre-identifies anthropogenic and biophysical landscape features that can be leveraged to increase the safety and effectiveness of wildfire management operations. We use a case study from the United States to illustrate the development and application of tools that draw from research generated by the global fire management community.

Paveglio, T. B., Nielsen-Pincus, M., Abrams, J., & Moseley, C. (2017). Advancing Characterization of Social Diversity in the Wildland-Urban Interface: An Indicator Approach for Wildfire Management. *Landscape and Urban Planning, 160*, 115-126 https://doi.org/10.1016/j.landurbplan.2016.12.013

A growing body of research indicates that communities at risk from wildfire differ in terms of the local social context that influences adaptive planning, mitigations or collective actions. Less work has attempted to document critical differences in that local social context across large samples. The research presented here explores a quantitative operationalization of an established framework for characterizing the social diversity of communities at risk from wildfire. We conducted structured interviews with key informants across nine U.S. states. Factor analysis, regression and hierarchical cluster analysis were used to characterize social context across communities and relate it to key informant evaluations of progress toward fire adaptation. Our results advance methods to systematically document how social context influences local wildfire adaptation by: (1) examining a preliminary set of quantitative key-informant measures for gauging social context across a range of WUI communities; (2) identifying related elements of social context that may collectively influence wildfire adaptations; (3) providing preliminary statistical evidence that highly related elements of local social context are correlated with expert assessment of local populations' adaptations to wildfire; and (4) identifying differences in social context characteristics across a sample of western USA WUI communities. However, it also is important to recognize that the measures tested here serve as indicators of deeper conceptual understandings informed by in-depth case studies. Efforts to use these measures should be augmented with additional qualitative work and build from those deeper understandings by considering the complexity of local dynamics surrounding wildfire management.

Rapp, C., Rabung, E., Wilson, R., & Toman, E. (2020). Wildfire Decision Support Tools: An Exploratory Study of Use in the United States. *International Journal of Wildland Fire, 29*, 581-594 https://doi.org/10.1071/WF19131

In the United States, many decision support tools exist to provide fire managers with weather and fire behaviour information to inform and facilitate risk-based decision-making. Relatively little is known about how managers use these tools in the field and when and how they may serve to influence decisions. To address this gap, we conducted exploratory interviews with 27 wildfire management and fire weather professionals across the United States. Results reveal that barriers to the use of decision support tools are structural and social. Specifically, fire weather and behaviour models may not generate reliable output and managers may not use the information they provide, but technical specialists on incident management teams (IMTs) play an active role in trying to overcome these barriers through their technical expertise and their relationships with other members of the IMT. Although researchers suggest tools such as the Wildland Fire Decision Support System (WFDSS) inform broad, strategic decision-making for line officers and IMTs, our results suggest fire weather and behaviour models are also important for communication and strategic or tactical planning within the IMT, especially for operations. We find that ultimately, managers may make use of fire weather and behaviour models, but they do not dictate decisions.

Reiners, D. (2012). Institutional Effects on Decision Making on Public Lands: An Interagency Examination of Wildfire Management. *Public Administration Review, 72*, 177-186 https://doi.org/10.111/j.1540-6210.2011.02486.x

A significant increase in catastrophic wildfires in the interior West of the United States has left public land agencies scrambling to reduce dangerous fuel loads and manage forests according to an ecological understanding of fire and forest health. However, this has not translated into standardized on-the-ground fire and fuel management in public land agencies. Different on-the-ground management practices raise questions about the extent to which ecosystems management is being utilized and how well land agencies are adapting to their new responsibilities. This study employs an institutional analysis and development framework to examine how and why on-the-ground decisions and outcomes differ. Decisions and outcomes are discussed as a function of the multiple layers of institutions that guide and constrain the decision processes of line officers who are responsible for developing and executing fire and fuel management projects.

Schultz, C. A., Miller, L. F., Greiner, S. M., & Kooistra, C. (2021). A Qualitative Study on the Us Forest Service's Risk Management Assistance Efforts to Improve Wildfire Decision-Making. *Forests, 12* https://doi.org/10.3390/f12030344

To support improved wildfire incident decision-making, in 2017 the US Forest Service (Forest Service) implemented risk-informed tools and processes, together known as Risk Management Assistance (RMA). The Forest Service is developing tools such as RMA to improve wildfire decision-making and implements these tools in complex organizational environments. We assessed the perceived value of RMA and factors that affected its use to inform the literature on decision support for fire management. We sought to answer two questions: (1) What was the perceived value of RMA for line officers who received it?; and (2) What factors affected how RMA was received and used during wildland fire events? We conducted a qualitative study involving semi-structured interviews with decision-makers to understand the contextualized and interrelated factors that affect wildfire decision-making and the uptake of a decision-support intervention such as RMA. We used a thematic coding process to analyze our data according to our questions. RMA increased line officers' ability to communicate the rationale underlying their decisions more clearly and transparently to their colleagues and partners. Our interviewees generally said that RMA data analytics were valuable but did not lead to changes in their decisions. Line officer personality, pre-season exposure to RMA, local political dynamics and conditions, and decision biases affected the use of RMA. Our findings reveal the complexities of embracing risk management, not only in the context of US federal fire management, but also in other similar emergency management contexts. Attention will need to be paid to existing decision biases, integration of risk management approaches in the interagency context, and the importance of knowledge brokers to connect across internal organizational groups. Our findings contribute to the literature on managing change in public organizations, specifically in emergency decision-making contexts such as fire management.

Thompson, M., Calkin, D., Scott, J. H., Hand, M., Riley, K., & Webley, P. (2017). Uncertainty and Probability in Wildfire Management Decision Support: An Example from the United States. *223*, 31-41 Retrieved from https://www.fs.usda.gov/treesearch/pubs/53458

Wildfire risk assessment is increasingly being adopted to support federal wildfire management decisions in the United States. Existing decision support systems, specifically the Wildland Fire Decision Support

System (WFDSS), provide a rich set of probabilistic and risk-based information to support the management of active wildfire incidents. WFDSS offers a wide range of decision-support components, including fire behavior modeling, fire weather information, air quality and smoke management, economics, organization assessment, and risk assessment. Here we focus on WFDSS's provision of probabilistic information and how it can facilitate strategic and tactical decision making. However, the management of active wildfire incidents can be highly complex and subject to multiple uncertainties, only some of which are addressed by WFDSS. We review remaining uncertainties, including identified issues in how fire managers interpret and apply probabilistic information, and conclude with observations and predictions for the future direction of risk-based wildfire decision support.

Fire Weather Forecasting, Products, and Services

Clark, J., Abatzoglou, J. T., Nauslar, N. J., & Smith, A. (2020). Verification of Red Flag Warnings across the Northwestern Us as Forecasts of Large Fire Occurrence. *Fire, 3*(4), 60 https://doi.org/10.3390/fire3040060

Red Flag Warnings (RFWs) issued by the National Weather Service in the United States (U.S.) are an important early warning system for fire potential based on forecasts of critical fire weather that promote increased fire activity, including the occurrence of large fires. However, verification of RFWs as they relate to fire activity is lacking, thereby limiting means to improve forecasts as well as increase value for end users. We evaluated the efficacy of RFWs as forecasts of large fire occurrence for the Northwestern U.S.—RFWs were shown to have widespread significant skill and yielded an overall 124% relative improvement in forecasting large fire occurrences than a reference forecast. We further demonstrate that the skill of RFWs is significantly higher for lightning-ignited large fires than for human-ignited fires and for forecasts issued during periods of high fuel dryness than those issued in the absence of high fuel dryness. The results of this first verification study of RFWs related to actualized fire activity lay the groundwork for future efforts towards improving the relevance and usefulness of RFWs and other fire early warning systems to better serve the fire community and public.

Eastern Research Group. (2018). *Assessing Fire Weather Services from the Public Perspective.* Prepared for the National Weather Service. Lexington, MA. Retrieved from https://vlab.noaa.gov/documents/3655205/4357712/FINAL+Assessing+Fire+Weather+Services+from+the+Public+Perspective+060118.pdf/f0859996-a5db-cf23-ac07-6d28689dee13?t=1563134799688

Tens of thousands of wildfires occur each year, and the extent of area burned by wildfires appears to be increasing.1 Although wildfires can occur anywhere in the United States, Western states are at particular risk, and homes anywhere in the wildland-urban interface (WUI) will eventually be exposed to wildfire.2 These risks highlight the importance of effective messaging to alert people to wildfire threats and ensure they prepare for and respond appropriately when threatened with a wildfire event.

Current National Weather Service (NWS) fire weather products and services were created for the wildland fire management community and not intended for use by the public. However, over the years, these products have been commonly broadcast through media outlets and displayed on webpages. ERG was tasked with investigating how the public uses current NWS fire weather products and services, what actions the public takes using this information, and what information the public may need that is not

included in current NWS products and services to save lives and reduce impacts to property. This report addresses only the gap associated with not having a public fire weather product and not product needs for other stakeholder groups such as land managers and fire fighters.

Jolly, W. M., Freeborn, P. H., Page, W. G., & Butler, B. W. (2019). Severe Fire Danger Index: A Forecastable Metric to Inform Firefighter and Community Wildfire Risk Management. *Fire, 2* https://doi.org/10.3390/fire2030047

Despite major advances in numerical weather prediction, few resources exist to forecast wildland fire danger conditions to support operational fire management decisions and community early-warning systems. Here we present the development and evaluation of a spatial fire danger index that can be used to assess historical events, forecast extreme fire danger, and communicate those conditions to both firefighters and the public. It uses two United States National Fire Danger Rating System indices that are related to fire intensity and spread potential. These indices are normalized, combined, and categorized based on a 39-yr climatology (1979–2017) to produce a single, categorical metric called the Severe Fire Danger Index (SFDI) that has five classes; Low, Moderate, High, Very High, and Severe. We evaluate the SFDI against the number of newly reported wildfires and total area burned from agency fire reports (1992–2017) as well as daily remotely sensed numbers of active fire pixels and total daily fire radiative power for large fires (2003–2016) from the Moderate-Resolution Imaging Spectroradiometer (MODIS) across the conterminous United States. We show that the SFDI adequately captures geographic and seasonal variations of fire activity and intensity, where 58% of the eventual area burned reported by agency fire records, 75.2% of all MODIS active large fire pixels, and 81.2% of all fire radiative power occurred when the SFDI was either Very High or Severe (above the 90th percentile). We further show that SFDI is a strong predictor of firefighter fatalities, where 97 of 129 (75.2%) burnover deaths from 1979 to 2017 occurred when SFDI was either Very High or Severe. Finally, we present an operational system that uses short-term, numerical weather predictions to produce daily SFDI forecasts and show that 76.2% of all satellite active fire detections during the first 48 h following the ignition of nine high-profile case study fires in 2017 and 2018 occurred under Very High or Severe SFDI conditions. The case studies indicate that the extreme weather events that caused tremendous damage and loss of life could be mapped ahead of time, which would allow both wildland fire managers and vulnerable communities additional time to prepare for potentially dangerous conditions. Ultimately, this simple metric can provide critical decision support information to wildland firefighters and fire-prone communities and could form the basis of an early-warning system that can improve situational awareness and potentially save lives.

Lindley, T. T., Andra, D. L., Smith, R. D., Curl, T. S., Zwink, A. B., Speheger, D. A., . . . Witsaman, P. G. (2019). *Proposed Implementation of Warn-on-Detection Fire Warnings for Public and Firefighter Safety.* Paper presented at the 47th Conference Broadcast Meteorology/5th Conference on Weather Warnings and Communications. Retrieved from https://ams.confex.com/ams/47BC5WxComm/webprogram/Manuscript/Paper358595/Lindley_etal_2019.pdf

The lack of fire-specific warning protocols to influence public and firefighter safety has garnered widespread attention following recent national wildfire disasters. Meanwhile, both scientific knowledge of dangerous wildfire environments and the technology to remotely detect wildland fire ignition and behavior, have dramatically improved. Deployment of GOES16/17, and their Advanced Baseline Imagers

has revolutionized operational wildland fire detection and monitoring capabilities. National Weather Service (NWS) forecasters have leveraged GOES-16/17 era technology to provide real-time notifications of wildfires since 2016 (Lindley et al. 2016). In many cases, hot spot notifications are received prior to emergency 911 calls and have facilitated rapid response to fires that saved lives and property (NOAA 2018).

Owen, G., McLeod, J. D., Kolden, C. A., Ferguson, D. B., & Brown, T. J. (2012). Wildfire Management and Forecasting Fire Potential: The Roles of Climate Information and Social Networks in the Southwest United States. *Weather, Climate, and Society, 4*, 90-102 https://doi.org/10.1175/WCAS-D-11-00038.1

Continuing progress in the fields of meteorology, climatology, and fire ecology has enabled more proactive and risk-tolerant wildland fire management practices in the United States. Recent institutional changes have also facilitated the incorporation of more advanced climate and weather research into wildland fire management. One of the most significant changes was the creation of Predictive Services in 1998, a federal interagency group composed, in part, of meteorologists who create climate- and weather-based fire outlooks tailored to fire manager needs. Despite the numerous forecast products now available to fire managers, few studies have examined how these products have affected their practices. In this paper the authors assess how fire managers in the Southwest region of the United States perceive and incorporate different types of information into their management practices. A social network analysis demonstrates that meteorologists have become central figures in disseminating information in the regional interagency fire management network. Interviews and survey data indicate that person-to-person communication during planning phases prior to the primary fire season is key to Predictive Services' success in supporting fire managers' decision making. Over several months leading up to the fire season, predictive forecasts based on complex climate, fuels, and fire-risk models are explained to fire managers and updated through frequent communication. The study's findings suggest that a significant benefit of the information sharing process is the dialogue it fosters among fire managers, locally, regionally, and nationally, which better prepares them to cooperate and strategically plan for the fire season.

Roncoli, C., Breuer, N., Zierden, D., Fraisse, C., Broad, K., & Hoogenboom, G. (2012). The Art of the Science: Climate Forecasts for Wildfire Management in the Southeastern United States. *Climatic Change, 113*, 1113-1121 https://doi.org/10.1007/s10584-012-0526-1

This article illustrates how a wildfire risk forecast evolved iteratively based on stakeholder consultations. An assessment based on phone interviews indicates that such forecasts can assist fire management decisions, such as deployment of human, financial, and material resources and management of forest, timber, and habitats, and public safety. But careful attention to communication, collaboration, and capacity building is key to realizing this potential.

Wall, T. U., Brown, T. J., & Nauslar, N. J. (2017). Spot Weather Forecasts: Improving Utilization, Communication, and Perceptions of Accuracy in Sophisticated User Groups. *Weather, Climate, and Society, 9*, 215-226 https://doi.org/10.1175/WCAS-D-15-0055.1

Spot weather forecasts (SWFs) are issued by Weather Service offices throughout the United States and are primarily for use by wildfire and prescribed fire practitioners for monitoring local-scale weather conditions. This paper focuses on use of SWFs by prescribed fire practitioners. Based on qualitative, in-depth interviews with fire practitioners and National Weather Service forecasters, this paper examines factors that influence perceptions of accuracy and utilization of SWFs. Results indicate that, while several well-understood climatological, topographical, and data-driven factors influence forecast accuracy, social factors likely have the greater impact on perceptions of accuracy, quantitative accuracy, and utilization. These include challenges with building and maintaining relationships between forecasters and fire managers, communication issues around updating SWFs, and communicating forecast confidence and uncertainty. Operationally, improved quantitative skill in a forecast is always desirable, but key opportunities for improving accuracy and utilization of these forecasts lie in 1) enhancing the processes and mechanisms for communication between a Weather Forecast Office and fire practitioners—before, during, and after an SWFs is issued—and 2) working with the wildland fire community to experiment with forecast uncertainty and confidence information in SWFs and evaluate impacts of these approaches.

Other

Littell, J. S. (2018). Drought and Fire in the Western USA: Is Climate Attribution Enough? *Current Climate Change Reports, 4*, 396-406 https://doi.org/10.1007/s40641-018-0109-y

Purpose of Review I sought to review the contributions of recent literature and prior foundational papers to our understanding of drought and fire. In this review, I summarize recent literature on drought and fire in the western USA and discuss research directions that may increase the utility of that body of work for twenty-first century application. I then describe gaps in the synthetic knowledge of drought-driven fire in managed ecosystems and use concepts from use-inspired research to describe potentially useful extensions of current work. Recent Findings Fire responses to climate, and specifically various kinds of drought, are clear, but vary widely with fuel responses to surplus water and drought at different timescales. Ecological and physical factors interact with human management and ignitions to create fire regime and landscape trajectories that challenge prediction. Summary The mechanisms by which the climate system affects regional droughts and how they translate to fire in the western USA need more attention to accelerate both forecasting and adaptation. However, projections of future fire activity under climate change will require integrated advances on both fronts to achieve decision-relevant modeling. Concepts from transdisciplinary research and coupled human-natural systems can help frame strategic work to address fire in a changing world.