Meeting Summary

Fire Science and Management in an Uncertain Future:

Tools and Approaches for Managing Fire in Future Climates in the Southwest

Organizing Committee: Matt Brooks, Mike Chotkowski, Corey Gucker, Joe Holomuzki (Chair), Génie MontBlanc, Stacey Sargent Frederick, Barbara Satink Wolfson

Hosts: USGS science for a changing world; California Fire Science Consortium; Great Basin Fire Science Exchange; Southwest Fire Science Consortium

At a Glance:

- A four-hour virtual summit was held Dec. 1, 2020.
- Goal: To identify fire science/management needs, discuss tools and approaches to resource assessment and adaption strategies that promote sustainability in the southwestern US.
- Key concerns and challenges identified for addressing future uncertainties were: collaboration, community preparation, and climate changes (the "3 C's").
- Participants requested additional workshops to promote collaboration, interagency partnering and recognition, and the blending of knowledge sources.
- It was also recommended that future participants include researchers, managers, practitioners, and policymakers from a diverse organizations.
- 122 people from a broad array of agencies participated.

Introduction:

The overarching goal of this four-hour virtual Summit was to identify fire science and management needs and discuss tools and approaches to resource assessments and adaptation strategies that benefit and promote sustainability in bioregions in future climates in the southwestern United States (Department of Interior [DOI] Regions 8 and 10 [CA, NV, AZ]). Talks and breakout groups were structured by the major bioregions: 1) western forest (e.g., mixed conifer, subalpine), 2) desert (hot and cold, grassland, pinyon-juniper, sage-steppe), and 3) Mediterranean/chaparral.

A driver for the Summit arose in a U.S. Geological Survey (USGS) Southwest Regional Director/Cost-Center Director (CD) meeting in summer 2018 in San Diego, where CDs expressed a strong desire to help fire, land, and community managers, and policy makers with efforts broadly related to sustainable, robust fire management. Another driver was the uncertainty of no-analog landscapes in future climates in the Southwest. Identified as a focus a decade ago in the National Park Service (NPS) Climate Change Response Strategy (2010), and perhaps even more germane today: "Climate change will create novel communities and environments… Sometimes called 'no-analog' conditions, the future will be characterized by climatic and seasonal patterns for which we have no modern or historical reference." To address these no-analog conditions, together we must, in part, "begin with manager needs" and "build connections across disciplines and organizations." This Summit was designed to add to both proposed actions.

Specific objectives were to:

- Provide awareness of tools and approaches for decision-making in an uncertain future
- Generate a list of science and data needed to meet challenges in future, no-analog landscapes
- Suggest how we might facilitate accomplishing identified needs and integrate them into fire management
- Connect and network with other participants in similar fields and ecosystems

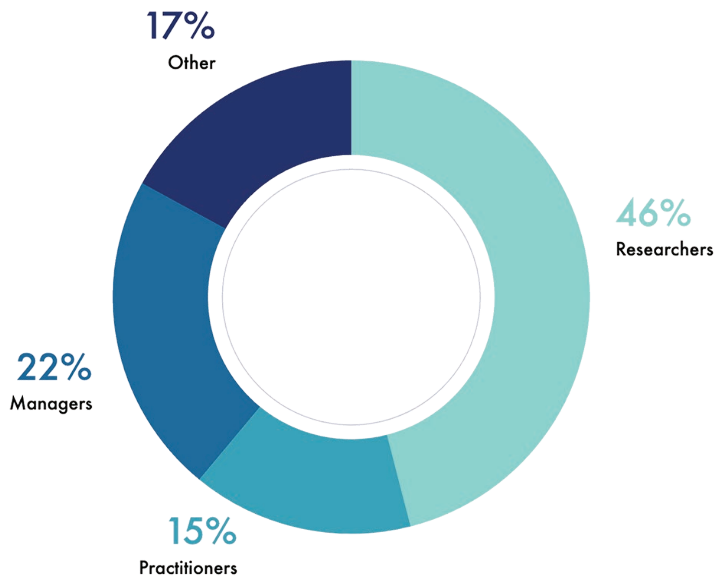
Participants:

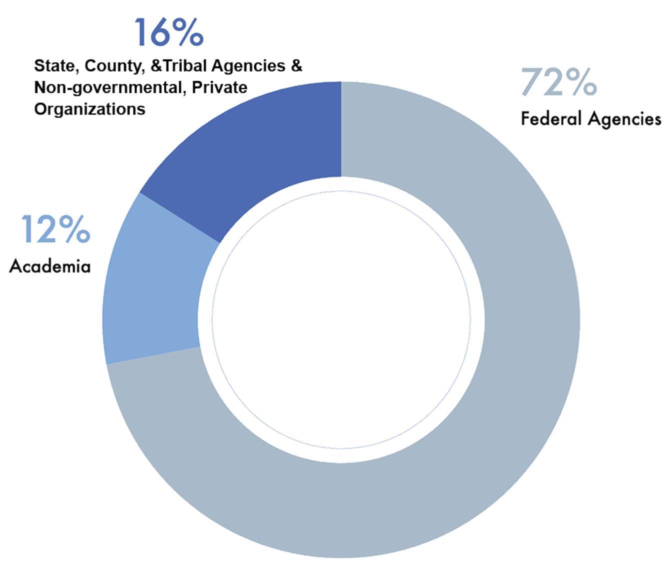
Of the 164 registrants, 122 individuals from a broad array of agencies participated in the Summit. Nearly half (46%) were researchers, 22% managers (with decision-making and supervisory responsibility), and 15% practitioners (with implementation responsibility). Moreover, 72% were from federal agencies, 12% from academia, and the remaining 16% from state, county, and tribal agencies and from non-government and private organizations.

Of federal-agency participants, 53 were from USGS, 17 from the U.S. Department of Agriculture, 6 from Bureau of Land Management (BLM), 4 from NPS. The remaining 6 participants were from federal affiliations including the U.S. Fish and Wildlife Service (USFWS), National Aeronautics and Space Administration, U.S. Bureau of Reclamation, Bureau of Indian Affairs (BIA), and Western Cohesive Wildland Fire Management Strategy. State, county, and tribal agencies represented were the Nevada Forestry Division, Sonoma County Water Agency, California Dept. Forestry and Fire Protection, Arizona Public Service Forestry Fire Mitigation, Institute for Tribal Environmental Professionals, and Hawaii Wildfire Organization. The Nature Conservancy was also represented as were the two private organizations, WUI Solutions and Forever Green Forestry.

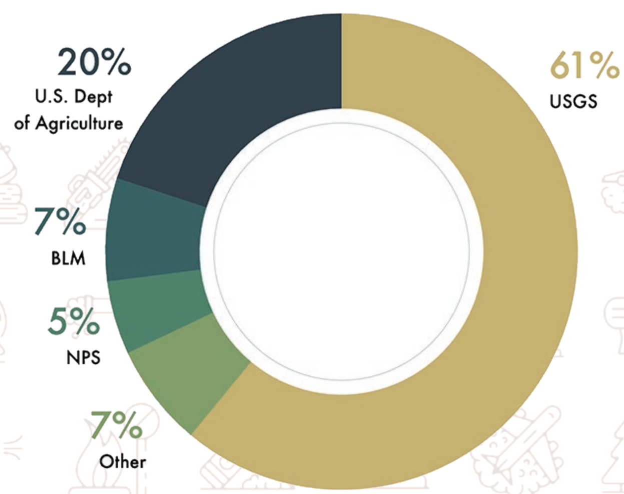
Live polling (Mentimeter®) was used to learn of participant backgrounds and affiliations, and key fire-related challenges, and to determine questions for speakers in Question & Answer (Q&A) sessions. Speaker presentations catalyzed discussion in Q&A and in breakout groups. Breakout groups, assembled by bioregion, brainstormed using the digital whiteboard Mural®. The results of these activities are described within this document, and the Specific Objectives Met can be found below beginning on page 10.

All Attendees





Federal Agency Participants



Summit Take-Aways

When asked what participants viewed as the most important 'take-aways' from the meeting, responses were nearly evenly distributed among: 1) Providing awareness of tools for decision-making in uncertain futures, 2) Generating novel science actions for practitioners and planners, 3) Suggesting how we might accomplish identified needs, 4) Exchanging information, and 5) Making connections (Fig. 1). When asked in word-cloud format what were key concerns and challenges in addressing future uncertainties, attendees identified: collaboration, community preparation, and climate changes (the "3 C's") (Fig. 2).

The "3 C's", along with the following key, nearly co-equal fire challenges/concerns, were also identified by registrants prior to the Summit:

- Forecast climate-change impacts on fire dynamics
- Work cooperatively to align tools and science with decision-making support
- Community preparedness and resilience
- Invasive vegetation fueling fires
- Post-fire recovery and restoration
- Impacts on watersheds and coastal systems

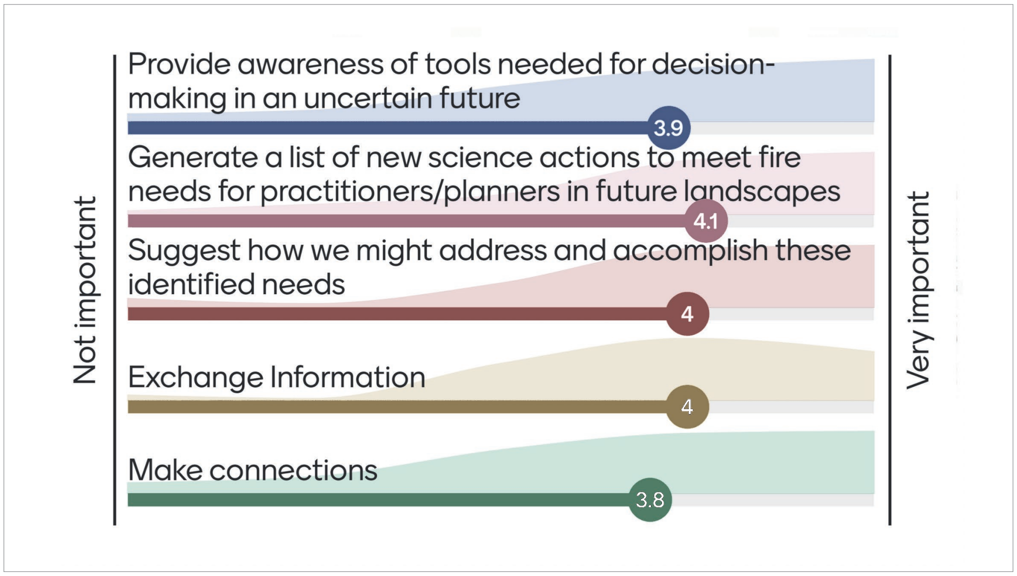


Figure 1. Result from polling participants on the question **'What is the most important walk-away' that you want to take from this meeting?'** Scaling is from 1 to 5, where 1 is the least important, and 5 is most important.

Figure 2.Word cloud generated from polling participants on the question **'What do you consider to be the biggest climate-wildfire challenge or concern from the following: research, recovery, community preparation, watershed impacts, fuels, climate change, collaboration, landscape evolution, or other?.'**

Talks

The purpose of talks was to catalyze discussion in the Q&A and breakouts. More specifically, talks generally addressed major climate-wildfire changes expected to affect fire management in bioregions, introduced tools and approaches to facilitate effective decision-making in uncertain futures, and suggested how these tools and approaches might be integrated into fire management. Affiliations and expertise of speakers were broad to help provide different perspectives on the organizational, ecological, and cultural complexities of fire and fire management in changing climates.

Collectively, the relationship-building message of 'we are in this together' resonated across talks. Talks, in order of presentation, were:

The Joint Fire Science Program and its Fire Science Exchange Network *Stacey Sargent-Frederick, Coordinator, California Fire Science Consortium, Berkeley, CA*

DOI's Joint Fire Science Program (JFSP) was established by Congress in 1998 and is jointly funded by the Departments of Interior and Agriculture. JFSP "funds scientific research on wildland fires and distributes results to help policy makers, fire managers, and practitioners make sound decisions". Its 12-member Governing Board has 6 members from the U.S. Forest Service (USFS) and 1 member each from the BLM, BIA, USFWS, NPS, USGS, and Office of Wildland Fire. The JSFP funds and manages the Fire Science Exchange Network. The 15 fire-science exchanges accelerate the awareness, understanding, adoption, and implementation of readily available wildland fire science to Federal, Tribal, State, local, and private stakeholders within ecologically similar regions. Example products include research briefs, newsletters, webinars, and research support, and example activities include field trips, workshops, conferences, and classes.

Aligning fire science with fire needs *Paul F. Steblein, Wildland Fire-Science Coordinator, USGS, JSFP Governing Board*

Relationships between fire, land, emergency, and community managers, and policy makers are critical for sustainable, robust fire management in uncertain futures. Building relationships and structure across organizations better defines fire challenges and needs, facilitates the sharing of information and tools, and leverages resources. What tools and information to extract, share, and use from the existing abundance of information on the drivers of fire behavior can be challenging for fire managers and practitioners. Querying stakeholders from various affiliations nationwide revealed that climate change and its impacts on fuels and fire behavior were high priorities for planning for future uncertainty and risk.

Co-owning fire: people, relationships, and networks are the key to our fire future *Lenya N. Quinn-Davidson, Area Fire Advisor, University of California, Agriculture and Natural Resources*

Networking, building capacity, and changing culture are key to addressing fire challenges now and in the future and can be achieved by five scalings: 1) 'scaling-up' to change institutional ideas and norms, 2) 'scaling initial conditions' to change access to capital, data, and knowledge, 3) 'scaling out' to increase impacts on communities and people, 4) 'scaling deeper' to change relationships, values, and beliefs, and 5) 'scree scalings' to legitimize different small but relevant solutions. Legitimizing relevant community-based solutions can build capacity and provide solutions that preserve cultural values and beliefs in future local fire planning. The worldwide Prescribed Fire Training Exchange (TREX) brings a diverse group of practitioners together to learn together and to help build administrative infrastructure to enable knowledge sharing and cooperative burning.

Co-production of science and tools to help manage for climate change now: Southwest FireCLIME *Andi E. Thode, Professor of Fire Ecology and Fire Science, Northern Arizona University*

Southwest FireCLIME is a model of co-production where managers and scientists work together from start to finish on needs and solutions to plan for fire-climate challenges. By working collaboratively, models, vulnerability assessments, and a menu of fire-climate adaptation strategies were developed to facilitate effective fire management and actions in various climate scenarios. By bringing organizations together, funding, time, and knowledge can be leveraged to more efficiently address fire needs now and in the future.

Climate tools for fire management in southwestern forests *John T. Abatzoglou, Associate Professor in Management of Complex Systems, University of California Merced*

Climate is the interannual enabler of fire extent in Southwest forests. Climate change will produce hotter, drier conditions that will affect vegetation type and abundance, invasive grass spread, fuel loads and flammability, and hence fire behavior and land management practices. Fuel aridity roughly doubled in western forests from 1984 to 2015. Anthropogenic climate-change influences on fuel aridity are projected to increase wildfire potential across western forests in coming decades and pose significant threats to ecosystem services, human health, and fire suppression budgets. The forthcoming Interactive Climate Analog Tool will allow managers to find a climate most similar to what is projected for a site in the future, and hence, hopefully greatly help managers with future long-term planning.

Altered fire regimes and wildfire management of sagebrush ecosystems *Michele R. Crist, BLM, Fire and Aviation, National Interagency Fire Center*

In contrast to historic trends, contemporary fire cycles in hotter-drier lower elevations across the sagebrush biome in NV, OR, and ID are: 1) shorter, inhibiting system recovery, 2) reburning at faster intervals, and 3) increasing in burn area and fire size. These changes are exacerbated by the encroachment and spread of invasive cheatgrass (*Bromus tectorum*). Altered fire regimes and plant communities impact many ecosystem services, such as wildlife and livestock forage, soil retention, and recreational activities, and alter cultural practices. Integration between state and federal invasive species programs and wildland fire management programs could decrease fire management costs, decrease risk to human life and property, decrease the loss of natural and cultural resources, help preserve wildlife, and halt habitat fragmentation through coordinated, large-scale management of non-native annual grasses and wildfire. Science Framework 1 and 2 are tools that assess system successional trajectories and prioritize management sites for invasive species reduction. Policy and cultural changes need to occur to address the unique aspects of fire in shrublands and to promote the public's understanding of fire. More research is needed to test strategically placed fuel treatments and "invasive fuels" reduction strategies, assess the effectiveness of large-scale, invasive reduction methods, and better understand native plant successional trajectories of sagebrush communities after natural disturbance.

Climate change implications for post-fire resource management in a Sonoran Desert-montane ecotone: Considerations from the Big Horn Fire *Carolyn A. Enquist, Deputy Director, USGS Southwest Climate Adaptation Center, and Molly E. Hunter, Natural Resources and the Environment, University of Arizona*

The Big Horn Fire in the Santa Catalina Mountains north of Tucson, AZ, in June 2020, which threatened over 80 miles of wildland-urban interface and burned nearly 120K acres, was a preview for future fire events in the region. Climate change in the Southwest will bring hotter and drier conditions with increasingly episodic and extreme participation events, exacerbating the spread of invasive grasses, and hence, increase the threat of fire in the non-fire adapted Sonoran Desert. A holistic approach to fire management should include cross-jurisdictional, coordinated fuels reduction, with year-round invasive grass removal in lower elevations, prescribed burning in fire-adapted ecosystems in upper elevations during cool seasons, and integrated watershed planning across elevations to mitigate post-fire flooding and erosion. Given the complexity of this approach, which involves balancing eco-integrity and water availability with human property, development, and recreation, fostering connections to public values and engaging in public education on the differing roles of fire are critical to facilitate community buy-in on future planning and decision-making.

New tools, methods, and partnerships for chaparral sustainability *Hugh D. Safford, Regional Ecologist, USFS and Research Faculty, University of California Davis*

Overly frequent fires are a key source of chaparral degradation In Southern California. Historically, chaparral was characterized by a closed-canopy and a high diversity of native species adapted to severe but relatively infrequent fire (every 30-100 years). Today much chaparral habitat is degraded due to a variety of factors, including highly frequent human-caused fires, invasion by exotic grasses, heavy inputs of atmospheric pollutants, and some of the most severe climatic warming in the U.S.

A projected reduction in shrublands and a 50-1500% increase in grasslands coincides with a significant degradation in ecosystem services, such as biodiversity, sediment retention, water quality, and carbon storage. Multiple joint efforts by the U.S. Forest Service underway to conserve and sustainably manage chaparral include the: Triannual Chaparral Symposium, SoCal Ecosystem Services Assessment (ESA), Postfire Restoration Planning (PReP) Tool, and Pacific SW Region Post-fire Restoration Framework. The SoCal ESA measures and values five ecosystem services in chaparral landscapes and allows managers to estimate the probable impacts of fire, climate change and management actions on those services. PReP assesses regeneration capacity of chaparral after fire, identifies areas of potential ecosystem degradation, and prioritizes area for restoration. The Postfire Restoration Framework is intended to guide the development of post-fire restoration actions on national forest and other lands in California. The framework is guided by principles of ecological restoration and includes a landscape assessment process and tools, as well as a framework for decision-making to plan and implement restoration projects.

Climate change, eco-culture, & resilience for SW indigenous/tribal communities *Nikki E. Cooley, Institute for Tribal Environmental Professional's Tribal Climate Change Program*

The Institute for Tribal Environmental Professional's Tribal Climate Change Program emphasizes both cultural and environmental management in climate-change adaptation planning. Fire is a relative to native peoples, who have long practiced co-production of knowledge with mother earth, father sky, water, and animals. The resiliency of indigenous peoples is again challenged, as we must adapt more quickly, as climate change quickens. Tribal nations must work together to deal with the long-term impacts of climate change and bridge traditional knowledge with current fire-science knowledge when developing climate-adaptation plans.

Breakout Groups

Breakout groups using Mural® addressed three questions:

1) What major climate-wildfire changes are expected to affect fire management in your bioregion?

2) What tools/data/science are needed to address these changes?

3) How do we facilitate the generation of new science and integrate it into fire management?

Changes expected to affect fire management that were common across bioregions were increases in climate-driven landscape flammability and altered fire regimes, and their potential impacts on human health and property, and ecosystem services (Table 1).

Additional concerns shared across bioregions were greater climatic variability, invasive species spread, more frequent, larger fires, worsening impacts on water resources and air quality, and increased human populations in the Wildland-Urban Interface (WUI). Examples of bioregion-specific expected changes were a westward shift in monsoons that could increase aridity in deserts and changes in offshore winds that would increase aridity and fuel drying in western forests. Many tools, approaches, and data sets were posited to address these challenges (Table 2).

However, it was generally suggested that fire prediction models be improved using satellite and in situ data, public education on wildfires be improved, capacity in fuel-reduction treatments be built, an economic prioritization process be used in management, a fire workforce be trained with knowledge and skillsets in prevention, mitigation, and suppression, more prescribed burns be done in cooler seasonal windows, and more cross-agency, cross-jurisdictional projects be done (Table 2).

To help integrate these suggestions into fire management, regardless of bioregion, it was recommended that partnership building, interagency collaboration, and cross-agency funding be promoted, communication with policy-makers be improved, funding to boundary organizations (e.g. fire-science exchanges, climate-adaptation centers) be increased, targeting relevant data to managers be improved, co-production be promoted and institutionalized, and collaboration with reinsurance and insurance providers be promoted (Table 3).

Table 1. Responses to the question:

What major climate-wildfire changes are expected to affect fire management in western forest, desert, and Mediterranean/ chaparral bioregions?'

Western Forest

- Increased climate-driven landscape flammability
- Lower soil moisture, drier vegetation and fuels, increased fuel loading, and shrinking precipitation windows
- Earlier snowpack melt
- Increased fire severity, longer fire seasons, and more re-burns
- Increased temperatures bringing increases in disease, invasive species, and insect outbreaks
- Increasing number of unnatural fire ignitions
- Increased smoke and air-quality issues
- Increased risk to fire fighters
- Increased threat to the tourist industry
- More post-fire debris flows
- Increased human populations in the WUI
- Further limitations on fire personnel and resources
- Greater impacts on water resources
- Offshore wind events (e.g. Santa Ana) drying fuels and increasing aridity

Photos by Stacey Frederick

Desert

- Different deserts will experience different, altered precipitation regimes
- Monsoons may be pushed westward and increase aridity
- More frequent and larger fires over a longer, or year-around, wildfire season
- Increased invasive-plant dominance, leading to different, more flammable fuel types
- Loss of native habitat with landscape conversion
- Greater climatic variability
- Longer times for ecosystem recovery
- Increased soil erosion due to loss of plant and biocrust cover
- An increased WUI
- Increase in release of greenhouse gases
- Changes in the effectiveness of fuel breaks

Mediterranean/chaparral

- Forest conversion to shrubland and grassland
- Less fog, hotter and drier climate, larger storms, greater variability in precipitation, and more dry lightning
- Increasing prevalence of multiyear drought
- More frequent, larger, and severe wildfires
- Worsening air-quality impacts
- An increased WUI, as human populations grow into fire-prone areas
- Increased erosion management, particularly into waterways
- Increased risk of catastrophic debris flows
- Changing burn windows for more prescribed burns

Table 2. Responses to the question:

'What tools/science/data are needed to address these climate-wildfire changes that will affect fire management in bioregions?'

Western Forest

- Tools that help address future, no-analog environments
- Better incorporation of remote-sensing and ground-truthing data in fire modelling
- Real-time apps for fire conditions and risk
- Better field observations of fuel types and moisture for better forecasting
- An economic prioritization process for forest management
- Measurements of sediment, water quality, and reservoir capacity downstream of wildfires
- Tools that improve efficiency as to where prescribed burning and thinning occurs to decrease landscape flammability
- Regionally consistent datasets
- Improve communication with communities where Foehn wind events occur, and improve evacuation preparation
- Fuel breaks that can stand extreme weather
- Improve shut-off to power grids
- Burn bosses with a variety of ecotype experiences
- Health impact and vulnerability assessments
- Fire workforce with knowledge and skill sets in prevention, mitigation, and suppression

Desert

- Future invasive plant risk prediction mapping
- Predict fuel conditions under different climate scenarios and vegetation types
- More data on fire effects of soil species relating to restoration trajectories
- Practical landscape-scale restoration options from an economic and implementation standpoint
- Increased public education on fire to an increasing WUI population
- Future scenarios that integrate facets of climate change, fuels, fire weather, human development, and management realities
- More climate variability data and better, downscaled climate models
- Doing more prescribed burns in seasonal windows
- Identify best practices to control invasive vegetation
- Improve fire models for non-forests
- Use citizen science for data collection and engagement
- Improve native-plant seed technology to improve restoration success
- Analyze how monsoons might shift and affect fire behavior
- Predictive models for post-fire successional trajectories

Photos by Stacey Frederick

Mediterranean/chaparral

- High resolution climate data that informs vegetation and fuel maps and simulations
- Advanced remote-sensing techniques to monitor fuels and soil moisture
- Watershed models for surface hydrology, and sediment, nutrient, and contaminant transport pre- and post-fire
- Long-term experimental watershed studies
- More data on mercury transport in smoke, air, and water during and after fires
- Social science investigations addressing chronic risk of severe fires
- More information on fire and burn histories in regions
- Social network analysis to build relationships with and among landowners
- Better understanding of fire patterns on wildlife diversity
- More precise weather forecasting integrated with modelling of wildfire impacts on ecosystem processes
- More information on post-fire ecosystem recovery and resource investment
- Tools showing the relationship between smoke and aerosol composition and health effects that are easily relatable to the public

Photos by Stacey Frederick

Table 3. Responses to the question:

'How do we facilitate the generation of new tools/science and integrate them into fire management' grouped by Partnering, Building Capacity, Funding, Communication and Public Awareness, and Planning.

Partnering

- Invest in cross-disciplinary, multiagency, cooperative research
- Identify, and partner with, remote sensing developers and key people or groups that are agents of change
- Improve and incentivize partnerships and collaborations among researchers, managers, agencies, and industry
- Provide resources for, and institutionalize, co-production
- Promote interagency coordination to identify highest, common priority needs
- Improve coordination with the Institute for Tribal Environmental Professionals and tribes
- Promote interagency collaboration, cross-agency funding, and partnerships with the private sector in fire tool development
- Promote collaboration with reinsurance and insurance providers

Planning

- Commit to long-term investigations
- Periodically update fire management and resource plans to reflect developing understanding of fire-climate relationships
- Do more hazard-event scenario planning
- Stop producing similar tools in parallel
- Leverage for long-term remote sensing and artificial intelligence capabilities

Building Capacity

- Invest in cloud infrastructure, artificial intelligence, and machine learning for timely modelling and communication
- Improve focus on fire ecology in fire-fighter training
- Add different kinds of researchers with different expertise to better understand fire
- Increase capacity for identified priority needs
- Provide easy tools for vulnerability assessments
- Support training for fire managers on resource issues, tools, and collaborative management
- Invest in field training and peer exchanges between ecotypes
- Create catalogues of data needs and existing sources
- Update and improve existing tools, when possible, vs. developing new ones
- Build capacity in public education on awareness of climate change and the value of fuel reduction treatments
- Build a leadership that will improve institutional capacity

Funding

- Increase Joint Fire Science Program funding
- Allow for more spending flexibility in management to facilitate long-term strategies
- Fund liaison positions that crossover between science and management
- Increase funding to boundary organizations (e.g. Fire-Science Exchanges, Climate Adaptation Centers)
- Build pre-fire management needs into federal appropriations

Communication and Public Awareness

- Better promote community participation in fire prevention and protection
- Improve media campaigns to improve public education of fire's differing roles
- Improve public education on how humans can adapt to changing climate conditions
- Build awareness and support of the public and appropriators through better communication and success stories
- Hold more virtual meetings for knowledge exchange and to stay closely connected to stakeholders and policymakers
- Improve targeting of relevant data to managers

Specific Objectives Met

Objective 1: Provide Awareness of Tools and Approaches for Decision-Making.

Speakers discussed a variety of tools and approaches to aid decision-making in future climates. Lenya Quinn-Davidson detailed the five scalings to address fire challenges now and in the future, and the TREX (training exchange) model that promotes shared learning and cooperative burning by practitioners. Andi Thode shared the SW FireCLIMEmodel of co-production that provides vulnerability assessments and a menu of fire-climate adaptation strategies to facilitate effective fire management in various climate scenarios. John Abatzoglou introduced the Interactive Climate Analog Tool which should greatly help managers with future long-term planning in novel landscapes. Michelle Crist discussed Science Framework 1 and 2 that assess system successional trajectories and how to prioritize management sites for invasive species reduction. Hugh Safford detailed multiple joint efforts (Triannual Chaparral Symposium, SoCal Ecosystem Services Assessment, Postfire Restoration Planning Tool, and Pacific SW Region Post-fire Restoration Framework) by the USFS to conserve and sustainably manage chaparral. Carolyn Enquist called for a holistic approach to fire management in the Sonoran Desert that includes cross-jurisdictional, coordinated fuels reduction, with year-round invasive grass removal in lower elevations, prescribed burning in fire-adapted ecosystems in upper elevations during cool seasons, and integrated watershed planning across elevations to mitigate post-fire flooding and erosion. Nikki Cooley discussed the need for tribal and non-tribal entities to consult each other and work together to bridge traditional knowledge with current knowledge in decision making if we are to achieve resilience. Many attendees noted that “talks were insightful and exciting.” One attendee stated, “There are useful tools out there, but they are not necessarily coordinated or widely known,” which speaks to a need for improved multiagency, cooperative research and improved targeting and sharing of relevant information to managers.

Objective 2: Generate a List of Science and Data Needs.

Table 1, but particularly Table 2, generated by participants in the Mural® exercise, lists actionable science topics and data needed to meet challenges in no-analog landscapes. Two post-meeting evaluative comments relevant to this objective were: “Impressive contributions on science topics in the breakout sessions” and breakouts by bioregion provided “areas of effort needed in desert biomes” and “non-forested ecosystems.”

Objective 3: Suggest How We Might Facilitate Accomplishing Identified Needs.

Table 3 provides a wealth of suggestions on how we might facilitate the generation of new tools/science and integrate them into fire management through partnering, capacity building, funding, improved communication and public awareness, and planning. Relevant post-evaluative comments on this objective included: [I gained] “a greater understanding of fire management challenges outside of forests” and became aware of the “commonality of problems across biomes.”

Objective 4: Make Connections.

Virtual meetings are a challenge for making personal and professional connections. One participant noted, [I] “Miss the one-on-one engagement that is so rich at in-person meetings.” However, breakout groups where participants were mixed by affiliation and job role facilitated networking. One participant commented: “I learned of new people to connect with,” and another stated, “It worked pretty darn well using the technology! In some ways, it is more intimate than an in-person workshop.” More broadly, many participants echoed a need for more collaboration, and that we must “build tribal partnerships” and “need strengthening of partnerships across agency boundaries.” Paul Steblein, Nikki Cooley, and Michele Crist particularly emphasized the need to work together to address future challenges posed by climate change and wildfires.

Next Steps

A future meeting focusing on the ‘3C’s’, climate change, community preparation, and collaboration, seems appropriate, given participants identified these as their major concerns/challenges. Responses in the Mural® exercise and in a post-meeting evaluation suggested that “more workshops like this one” be held that promote a transformation of fire science and management through collaboration, interagency partnering and recognition, and the blending of knowledge sources. It was also recommended that participants include researchers, managers, practitioners, and more policymakers from a diverse array of fire-interested organizations.

References

National Park Service. 2010. National Park Service Climate Change Response Strategy. National Park Service Climate Change Response Program, Fort Collins, Colorado. 28 p.

Thode, A.E. et al. 2020. Southwest FireCLIME: Research and resources for managing fire in a changing climate. Available: https://swfireclime.org/

Friggens, M.; Loehman, R.; Thode, A.; Flatley, W.; Evans, A.; Bunn, W.; Wilcox, C.; Mueller, S.; Yocom, L.; Falk, D. 2019. User guide to the FireCLIME Vulnerability Assessment (VA) tool: A rapid and flexible system for assessing ecosystem vulnerability to climate-fire interactions. Gen. Tech. Rep. RMRS-GTR-395. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 42 p.

Joint Fire Science Program. 2020. The Joint Fire Science Program: Research supporting sound decisions. Available: https://www.firescience.gov/

The Nature Conservancy. 2020. Prescribed Fire Training Exchanges. Available: https://www.conservationgateway.org/ConservationPractices/FireLandscapes/HabitatProtectionandRestoration/Training/TrainingExchanges/Pages/fire-training-exchanges.aspx

Chambers, J.C. et al. 2017. Science framework for conservation and restoration of the sagebrush biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to long-term strategic conservation actions. Part 1. Science basis and applications. Gen. Tech. Rep. RMRS-GTR-360. Fort Collins, CO: U.S Department of Agriculture, Forest Service, Rocky Mountain Research Station. 213 p. Available: https://greatbasinfirescience.org/research-publications/science-framework/

Crist, Michele R. et al., eds. 2019. Science framework for conservation and restoration of the sagebrush biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to long-term strategic conservation actions. Part 2. Management applications. Gen. Tech. Rep. RMRS-GTR-389. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 237 p. Available: https://greatbasinfirescience.org/research-publications/science-framework/

US Department of Agriculture, Forest Service. 2020. WWETAC Focus Area: SoCal EcoServe-Post-fire ecosystem services assessment tool. Available: https://www.fs.fed.us/wwetac/brief/landscapes-socalecoserve.php