THE FIRE CONTINUUM CONFERENCE
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PREPARING FOR THE FUTURE OF WILDLAND FIRE

M1. Homeowner Wildfire Preparedness: How Efficacy Affects the Relationship Between Risk Perception and Mitigation

Presenter: Claire Rapp, Graduate Student. The Ohio State University
Additional Authors: Wilson, Robyn, Associate Professor, The Ohio State University
McCaffrey, Sarah, Resarch Forester, United States Forest Service

Prior research indicates that the vast majority of residents in fire-prone areas have engaged in mitigation activity on their property, typically modifying the vegetation around their home to decrease wildfire risk. The research also indicates that the responsibility for mitigating wildfire risk is viewed as shared, with land owners responsible for mitigating the risk on his or her own property. Ultimately, the decision to engage in household level risk management is perhaps most influenced by the perceived risk associated with the hazard (in particular the perceived severity of the consequences of wildfire) and the perceived ability to effectively implement actions (i.e., high self-efficacy) and a belief in the likelihood of those actions actually reducing risk (i.e., high response efficacy, or a belief in the benefits of the behavior). Studies have also shown how the influence of perceived risk is moderated by the costs and benefits of a mitigation activity as well as other values that an individual may hold for their property (e.g., promoting privacy, providing wildlife habitat). In this study, we explored the direct impact of risk perception given different levels of self and response efficacy. Preliminary results indicate that the likelihood of having engaged in vegetation management or making structural changes to one's home increases with perceived risk. However, the effect of risk perception varies depending on how convinced a homeowner is that vegetation management or structural changes are effective. Analysis on the effect of self-efficacy, individual characteristics (e.g., age), and household characteristics (e.g. income) is still underway. These results indicate that efforts to promote fire preparedness behavior among homeowners would benefit not just from a focus on the likelihood of one's home burning during a wildfire event, but also from concrete evidence that such action can decrease the risk of losing one's home.

Keywords: preparedness, risk perception, homeowner, efficacy, mitigation

Bio: Claire Rapp is a graduate student advised by Dr. Robyn Wilson at The Ohio State University in the School of Environment and Natural Resources. She is interested in decision-making, risk, and the interactions between experts and non-experts in fire-prone areas of the Wildland Urban Interface.

M2. FireWorks Educational Program: Hand-on Activities to Engage Students and the Public about Wildland Fire Science

Presenter: Ilana Abrahamson, Supervisory Ecologist. US Forest Service, Rocky Mountain Research Station, Fire Sciences Lab

Wildland fire captures the public's attention every summer, but public understanding of fire is limited. The FireWorks Educational Program uses hands-on activities to increase the public's understanding of wildland fire. It is designed for students in Kindergarten through 12th grade, although many activities are suitable and fun for adults.

The original FireWorks Curriculum was first published in 2000 and consisted of about 30 activities featuring ecosystems in the Northern Rocky and Northern Cascade Mountains. The original curriculum was widely used by teachers and fire prevention, mitigation and education specialists, especially throughout the Northern Rocky Mountain region, but interest in the program stretched beyond this region. To address the widespread interest, we expanded, revised, and modernized the program. Today, FireWorks has new curricula for the Northern Rocky and Northern Cascade Mountains, Sierra Nevada, sage steppe, Missouri River Country, and we are developing a generic version.

The new curricula consists of new and updated activities that reflect recent advances in fire research and national educational standards. It includes activities that cover the physical science of wildland fire, the wildland fire environment, fire effects on the environment, fire ecology, fire history and succession, and people's relationships with fire.

This presentation will introduce the FireWorks program and showcase some of the exciting activities such as the matchstick forest model, campfire challenge, tinker tree derby, mystery trees, and buried treasures.

Keywords: Education, students, public, fire ecology, fire behavior

Bio: Ilana Abrahamson leads the Fire Effects Information System (FEIS, www.feis-crs.org/feis/) team of the Missoula Fire Sciences Laboratory, part of the U.S. Forest Services' Rocky Mountain Research Station. She also writes hands-on activities for the FireWorks educational program (www.frames.gov/fireworks/fireworks-home), which teaches students about the science of wildland fire. Ilana has a master's degree in forestry from the University of Montana and a bachelor's degree in environmental studies from Binghamton University.

M3. Preparing Youth Camps for Wildland Fire 2018
Presenter: Michael Jensen, Associate Professor. Washington State University

In this short presentation you will learn about ways WSU Extension is working with the American Camp Association to prepare Youth Camps for Wildland Fire in 2018. National presentations and cloud-based webinars are helping youth camps to assess their risks, review emergency and evacuation plans and reach out proactively to local fire and forestry agencies to lessen the impacts of wildland fire on there campers and communities.

Keywords: Youth Camps, Fire Prepardness, Partnerships

Bio: Mike Jensen is an associate professor with Washington State University Extension. He has spent 31 years work in Extension in Michigan, Florida and now Washington State. He is also a volunteer firefighter/wildland firefighter. He has been partnering with the American Camp Association and 4-H Youth Development across the Country to help prepare "camps" for wildland fire.

M4. Prescribed Fire Outreach: Develop Your Resources to Meet the Needs
Presenter: Jennifer Fawcett, Extension Associate. North Carolina State University
Additional Authors: Quinn-Davidson, Lenya, Area Fire Advisor, UC Cooperative Extension

As members of the fire community, we often talk about the need for more prescribed fire. But, are we prepared for everything that goes along with it? It might seem obvious that prescribed fire use comes with a need for prescribed fire outreach. However, with reductions in funding and an increase in workloads, it becomes harder to keep up with demand. Therefore, we must look for creative ways to collaborate, find means to better share existing resources, and only spend time creating new materials when they are truly needed. To determine if new prescribed fire related outreach materials are needed, an online needs assessment was conducted in 2017. The goals of the assessment were to to determine interest levels of natural resource professionals in conducting fire-related programming, to understand the types of prescribed fire materials and programs that are needed, and to collect the most useful existing materials that people are using today. A total of 387 people participated in the assessment. More than 80 percent of the respondents indicated that they are already carrying out some fire-related programming, however, 71 percent felt that if better prescribed fire resources and templates were available, they were either “likely” or “very likely” to conduct even more fire programming. This presentation will share the needs identified for both the type of resource (i.e., website, fact sheet, brochure, etc.) and topic area (i.e., smoke management, defensible space, etc.) for outreach to private landowners and homeowners. In order to provide the most value, it will be important to focus on these areas when developing new materials.

Keywords: Prescribed fire outreach, prescribed fire needs assessment

Bio: Jennifer Fawcett is an Extension Associate in the Department of Forestry and Environmental Resources, Extension Forestry at North Carolina State University. She serves as Coordinator the Southeast Regional Partnership for Planning and Sustainability (SERPPAS) Prescribed Fire Work Group and also assists in implementing prescribed fire-related education and outreach programs across the Southern region. She received her B.S. in Animal Science from the University of Delaware, M.S. in Forest Resources from Clemson University, and is working towards her Ed.D. in Agricultural and Extension Education at NCSU. She currently serves as an Advisory Board member for the Southern Fire Exchange.

M6. Using automated fuel sticks to estimate surface fine fuel moisture
Presenter: Jane Cawson, Research Fellow. University of Melbourne
Additional Authors: Petter Nyman, Christian Schunk, Gary Sheridan, Thomas Duff, Kelsy Gibos, William Bovill, Marco Conedera, Gianni Pezzatti and Annette Menzel

Field measurements of fuel moisture content (FMC) are integral to wildfire research, fire behaviour prediction and many fire danger rating systems. Yet, conventional measurement techniques are limited for a range of reasons including their labour-intensiveness and time-lags with sample processing. Automated fuel sticks (Campbell Scientific CS506/26601) offer a potential solution, providing a standardised, continuous and real-time measure of FMC. They are increasingly being incorporated into fire research and management as an analogue for fine fuel. However, there has been no systematic evaluation of their performance across different forest types and regions. To address this, the aim of this study was to evaluate the ability of automated fuel sticks to predict surface fine FMCs across a spectrum of forest types worldwide. Concurrent measurements of fuel stick and surface fine FMC from 27 study sites in Europe, Canada and Australia were combined to create a comprehensive fuel stick evaluation dataset (n=570). We found a moderate positive linear relationship between surface fine FMC and stick

FMC for all data combined (R^2 = 0.54), which suggests fuel sticks cannot be used as a direct analogue of surface fine fuels without fuel-specific calibrations. On average, surface fine FMCs were higher than stick FMCs by a factor of 3. However, the magnitude of that discrepancy varied between sites, and at very low FMCs it was reversed for some forest types. Linear regressions derived for individual forest types were generally stronger (median R^2 = 0.70). Our findings suggest that good estimates of surface fine FMC can be made following site-specific calibration against the fuel sticks, although error bands around those estimates may be too wide for some operational applications.

Keywords: fire danger; fuel moisture; hazard stick; 10-hour fuel

Bio: Jane is a forest scientist whose research examines bushfire behaviour and management, and its effects on vegetation and soil. Before embarking on her research career she worked in fire and emergency management for the State government of Victoria, Australia.

M7. The NIDIS Drought and Wildfire Nexus
Presenter: Timothy Brown, Research Professor. Desert Research Institute
Additional Authors: Tamara Wall, Associate Research Professor, Desert Research Institute

Drought impacts three key areas in the wildfire nexus - fire behavior, fire effects and fire management. The relationship between drought and wildfire is nuanced and complex, and wildfire management agencies would benefit from drought information products focused on wildfire, improved communication pathways for drought information exchange, and research targeted at relationships between climate and vegetation flammability. The National Integrated Drought Information System (NIDIS) Drought and Wildfire Nexus (NDAWN) was conceived to explore needs and challenges of drought information utilization in wildfire management, and begin identifying a drought and wildfire network. Through one national and several sub-regional workshops comprising state and federal fire management agency representatives, several key themes have emerged. The first of these is the need to improve communication between field staff and fire weather forecasters regarding field conditions and how rapidly they are changing, particularly in short-duration droughts or "flash droughts." The second is the perceptions of the workshop participants that drought could act as a catalyst to update fire policy and land management, particularly if framed using the three legs of the National Cohesive Wildland Fire Management Strategy-wildfire response, landscape resiliency and fire adapted communities. Third, drought tools specifically tied to fire relevance would help inform management decisions. Fourth, there is needed research to better understand the quantitative impacts of drought on fire. Fifth, there are regional desires to establish new or improve existing communication pathways for drought information. This micro talk presentation will briefly highlight findings from the NDAWN workshops emphasizing key themes, opportunities and needs, and describe the next steps in the NIDIS Drought and Wildfire Nexus effort.

Keywords: Drought, fire behavior, fire effects, fire management

Bio: Dr. Brown conducts applied research and applications development at the Desert Research Institute (DRI) in Reno, Nevada. His primary academic interests include wildland fire-climate and fire-weather connections; the wildfire environment; applications development for wildland fire management planning, decision-making and policy; the interface between science and decision-making. He is Director of the Western Regional Climate Center and the Program for Climate, Ecosystem and Fire Applications (CEFA) at DRI. He is graduate faculty in the Atmospheric Sciences Program at the University of Nevada, Reno, and quandom Monash University Adjunct in School of Earth, Atmosphere and Environment, Science Faculty in Clayton, Victoria, Australia.

M8. An improved National Fire Danger Rating System for the United States: NFDRS2016
Presenter: W. Matt Jolly, Research Ecologist. USFS, RMRS, Fire Sciences Laboratory
Additional Authors: Freeborn, Patrick, Research Physical Scientist, USFS, RMRS, Fire Sciences Laboratory

The United States National Fire Danger Rating System was developed nearly 40 years ago and it is used operationally to support both tactical and strategic fire management decisions nationwide. Since its inception, significant scientific advances in fuel moisture modeling and improved analytical tools have positioned system developers to make sweeping changes to the existing system while still maintaining its ability to adequately assess wildland fire potential across a range of biomes. Here we present the development of a simplified and improved fire danger rating system that can meet the needs of local, regional and national-level decision makers while remaining simple and relevant to operational firefighters. We detail the implementation of a physically-based fine dead fuel moisture model and a physiologically-based live fuel moisture model and we implement several other system simplifications, such as a reduction in the number of fuel models, that do not reduce the effectiveness of the system but that streamline the technology transfer of the new system. We compare results from the 1978 NFDRS version to this improved version and we show that even by considerable simplification, the efficacy of the system is maintained. Ultimately, this next-generation system paves the way for nationally-relevant fire danger rating system that can adequately depict fire danger across a range of climates and fuel types.

Keywords: fire danger, fire weather

Bio: William Matthew “Matt” Jolly is a Research Ecologist in the Fire, Fuel and Smoke Science Program of the US Forest Service, Fire Sciences Laboratory in Missoula, MT. He received a BA in Environmental Science from the University of Virginia and a PhD in Forestry from the University of Montana. He is also the project administrator for the research and development team of the Wildland Fire Assessment System (WFAS) and is continually evaluating and developing tools for landscape-scale fire danger assessment. His research explores how wildland fuel characteristics vary across space and time and how these variations impact wildland fire potential. Ultimately, his work will lead to improved wildland fire danger and behavior prediction tools.

M9. Do Outputs from the US National Fire Danger Rating System (NFDRS) Influence Fire Size?
Presenter: Nicholas Walding, PhD Candidate. University of Exeter
Additional Authors: Williams, Hywel, Senior Lecturer in Data Science, University of Exeter
McGarvie, Scott, Senior Research Fellow, University of Exeter
Belcher, Claire, Professor in Earth System Science, University of Exeter

Large wildfires in the USA are of growing concern due to their economic impacts, the suppression costs they incur, and their increasing occurrence in light of recent climate change and historic land-use practices. This study seeks to ascertain which physical and management factors play important roles in the formation of large wildfire events. By utilizing two previously unreconciled datasets, the NFDRS data archive and the USFS’s Fire Occurrence Database, we have created a dataset containing 12,369 fire events that details the fire danger conditions, represented by NFDRS outputs, for every day in each individual fire’s lifespan. We explore whether fire size is merely dependent on the duration of a fire’s burn period, or whether fire size relates to higher or more variable fire danger conditions present during

a fire's burn period. Initial findings from Principal Component Analyses indicate that as fire size increases, the importance of the duration of burning increases. Interestingly, the variability in fire danger experienced during a fire's lifespan appears to be more determinant of variations in fire size than the average fire danger experienced. The outcomes of this study could lead to new utility of the NFDRS daily outputs when considering the potential for large wildfires.

Keywords: Dire Danger Indices, Fire Size, NFDRS

Bio: Nicholas Walding is a PhD researcher in the wildFIRE Lab at the University of Exeter. He graduated from the University of Exeter with a first class BSc Geography (Hons) degree in 2014 and his current research explores the economic impact of large wildfire events and assesses the US National Fire Danger Rating System by relating records of fire activity and fire danger across temporal and spatial scales in order to aid future fire management. His previous research has aimed to identifying future fire threats associated with future shifts in vegetation distributions in North America.

M10. An Evaluation of the Forest Service Hazardous Fuels Treatment Program

Presenter: Nicole Vaillant, Fire Application Specialist. Forest Service, Rocky Mountain Research Station, Wildland Fire Management RD&A
Additional Authors: Reinhardt, Elizabeth, Retired Assistant Director, Forest Service

The National Cohesive Wildland Fire Management Strategy recognizes that wildfire is a necessary natural process in many ecosystems and strives to reduce conflicts between fire-prone landscapes and people. In an effort to mitigate potential negative wildfire impacts proactively, the Forest Service fuels program reduces wildland fuels.

As part of an internal program assessment, we evaluated the extent of fuel treatments and wildfire occurrence within lands managed by the National Forest System (NFS) between 2008 and 2012. We intersected fuel treatments with historic disturbance rates to assess the extent to which the program compensates for the disturbance deficit caused by fire suppression and with current wildfire hazard to evaluate whether fuel treatments strategically target high hazard locations. Annually, 45% of NFS lands that would have historically burned were disturbed by fuel treatments and characteristic wildfire, indicating that NFS lands remain in a "disturbance deficit." The highest wildfire hazard class had the lowest percentage of area treated and the highest proportion of both wildfire of any severity and uncharacteristically high-severity wildfire, suggesting that an alternative distribution of fuel treatment locations will probably improve program effectiveness.

Keywords: LANDFIRE, mechanical treatment, prescribed fire, resiliency, wildfire hazard

Bio: Nicole Vaillant has worked for the Forest Service for 15 years in a number of capacities. She is currently a Fire Application Specialist with the Wildland Fire Management RD&A and is based out of Bend, OR.

M11. Characterizing fire behavior across the globe

Presenter: Paulo Fernandes, Associate Professor. Centro de Investigação e de Tecnologias Agro-Ambientais e Biológicas (CITAB), Universidade de Trás-os-Montes e Alto Douro, Portugal
Additional Authors: Sil, Ângelo, Centro de Investigação e de Tecnologias Agro-Ambientais e Biológicas (CITAB), Universidade de Trás-os-Montes e Alto Douro, Portugal
Ascoli, Davide, Department Agraria, University of Naples Federico II, Italy
Cruz, Miguel, Bushfire Behaviour and Risks, CSIRO Land and Water, Australia

Rossa, Carlos, Centro de Investigação e de Tecnologias Agro-Ambientais e Biológicas (CITAB), Universidade de Trás-os-Montes e Alto Douro, Portugal
Alexander, Marty, Wild Rose Fire Behaviour, Canada

The environmental and societal impacts of fire depend of how fast it spreads, how much biomass consumes, and how much energy releases and at what rate. Nearly every feature of contemporary fire management relies upon the understanding and prediction of fire behavior characteristics and over the years a number of tools have been developed for such purpose in North America, Australia and Europe. Wildland fire science has been recently expanded to analyze fire activity and effects at the global scale but no attempts have been made so far to provide an overall worldwide picture of fire behavior characteristics, patterns and drivers. These are the general objectives of the BONFIRE project, requiring compilation of fire behavior information available from various sources (experiments, wildfires and prescribed fires) in a global database and the integrated analysis of variation in fire behavior characteristics. We are characterizing and synthesizing fire behavior patterns and assessing the influences of environmental drivers for biomes and broad vegetation types defined by composition and/or structure. Results are expected to provide a sound foundation for fire management and fire research applications and to increase the understanding of fire regime shifts in relation to global change.

Keywords: Fire behavior; Rate of spread; Fireline intensity; Fire environment; Modelling

Bio: Paulo Fernandes is an Associate Professor of Forestry. His research is mainly focused on the behaviour and ecology of wildland fire from the forest and fire management perspectives, mainly in topics of field-based assessment and modelling of fire characteristics and effects in various vegetation types.

M13. Fuels and fuel loading in the Fire Continuum

Presenter: Nancy French, Senior Scientist. Michigan Technological University
Additional Authors: Prichard, Susan, Research Scientist, University of Washington, Seattle
Kennedy, Maureen, Assistant Professor, University of Washington, Tacoma
Billmire, Michael, Research Scientist, Michigan Tech Research Institute
McKenzie, Donald, Research Scientist, USDA Forest Service
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Andreu, Anne, Research Scientist, University of Washington, Seattle
Eagle, Paige, Research Scientist, University of Washington, Seattle
Tanzer, Danielle, Research Associate, Michigan Tech Research Institute

Wildland fuels represent a key component in the Fire Continuum. The saying goes “Where there is Smoke there is Fire”. An extension along the Fire Continuum tells us: “Where there’s Smoke and Fire there is Fuel”. We review the need for understanding wildland fire fuels for all aspects of the fire continuum by characterizing with adequate fidelity the fuel type, structure, and loading. We emphasize the need for fuels information in emissions and smoke modeling, and report progress on a current Joint Fire Science Program project that addresses the idea that fuels are highly variable in space, time, and structure. This variability is clear to the wildland fire community, but the methods typically used to organize metrics of fuels for emissions and smoke modeling do not fully capture these realities. We are compiling data on fuel loading from multiple sources with the goal of fully describing the variability in fuel loading across the various fuel types represented in the Contiguous United States and Alaska. We will quantify this variability in a new map of fuel types and fuel loading for the domain. The fuel loadings database has been compiled with over 26,600 records representing 143 Existing Vegetation Groups

(EVG), and will serve as a “living database” to allow new data on fuels to be easily ingested. Early results suggest that variability in the more common fuel types is fairly “well behaved”, i.e., it can be summarized accurately by statistical metrics. Rarer fuel types, with small sample sizes, will require new data collection and compilation to inform statistical summaries. The resulting fuels map and database from this work will give smoke and air-quality modelers a tool for generating ensembles, similar to those in regional and global climate modeling, to inform emissions inventories and future projections.

Keywords: Fuel loading, emissions

Bio: Dr. French has been working on applications of remote sensing to ecology and vegetation studies for more than 25 years. Dr. French's research has focused on wildfires and their effect on the structure and function of ecosystems and the implications to carbon cycling, energy balance, and air quality. Her research has included studies in boreal, arctic, and temperate ecosystems with a variety of remote sensing systems and geospatial technologies. Dr. French is one of the leads of FASMEE, the Fire and Smoke Model Evaluation Experiment, which is focused on improving operational smoke modeling through a coordinated field campaign. She serves on the Editorial Board and as an Assistant Editor for the International Journal of Wildland Fire.

M14 Quantifying wildfire behaviour using observations from weather radar

Presenter: Thomas Duff, Research Fellow. University of Melbourne
Additional Authors: Chong, Derek, Programmer, University of Melbourne
Penman, T, Associate Professor, University of Melbourne

Wildfire behavior can rapidly change, so up-to-date intelligence is critical for managing firefighting and public safety. The ability of fixed site weather radars to detect the smoke plumes from fires has long recognized, however research has been limited in linking smoke plume observations to on-ground fire behavior. An advantage of using weather radar to monitor fires is that the radar infrastructure is already in place over large parts of the world, they operate at high temporal frequencies and have extensive coverage over populated areas.

We investigated the use of fixed weather radars for quantifying growth of large fires in south-eastern Australia, examining whether fire growth could be predicted by radar returns. This was done by obtaining fire spread isochrones for a series of 7 wildfires, and comparing the change in fire area per minute to the change in the 3-dimensional volume of radar returns in the vicinity of the fire. Relationships were evaluated with linear models. Radar return volumes were found to be a strong predictor of fire area change ($R2= 0.65$), and the relationship was consistent between fires. Forest fire growth could be robustly estimated using the radar signals, however fire spread in grass fuels appear to be less well represented. Our findings suggest that there is the potential to extend the use of weather radar to fire monitoring. In particular, the use of radar is likely to have value in providing wildfire intelligence at times of limited visibility and has the potential to provide early warning of potential escalations of fire behavior.

Keywords: bushfire; dBZ; detection; rain radar; plume; wildland fire;

Bio: Dr Duff is a forest scientist specialising in the quantitative analysis of fire problems. Much of his work is focused on operational problems and fire management needs. Before transitioning to research, Dr Duff trained and worked as a forester specialising in fire management and forest planning in South Eastern Australia. He is involved with projects on landscape fire risk, fire simulation, remote sensing, model performance, forest ecology and fire behaviour.

M15. Are fires faster in real life than in the lab?
Presenter: Bret Butler, Research Engineer. USFS
Additional Authors: Daniel Jimenez
Paul Sopko
Steve Quarles
Cyle Wold

Measurements of fire rate of spread were collected in a facility that has the capability to generate winds of constant speed and direction and also winds that exactly mimic the natural spatiotemporal variability found in the natural environment. The measurements show that in all cases fires spread fast when exposed to the natural versus constant winds with same average speed. Is this response due primarily to the peaks in the wind speed or the directional variability? While the data are limited they do provide a hint as the answer to this question.

Keywords: wind, fire

Bio: Bret is a research engineer at the Missoula Fire Lab. His work has focused on developing new understanding of how wind and fire interact.

M16. Experience, Commands, Training--drivers of firefighter's responses to fire behavior
Presenter: Tamara Wall, Research Scientist. DRI
Additional Authors: Brown, Timothy, Director, WRCC, DRI
Parkinson, Tami, Lead Fire Application Specialist, Wildland Fire Management Research Development and Application, USFS
Nauslar, Nick, Research Associate, NOAA Storm Prediction Center

The Fire Extremes project has gathered 227 micro-stories about wildland firefighters perceptions of extreme fire behavior, asking the questions about what types of fire behavior firefighters consider unusual, challenging, or unexpected. This talk looks specifically at a comparison of three variables: training, following orders/directions, and experience, to firefighter's perceptions of fire behavior unpredictability. We found indicators that suggest the more fire behavior is unpredictable or erratic, the less likely firefighters were to say they relied on training or following directions/orders and more likely to say they relied on experience. While experience is highly valued within the wildland management community, future climatic and fuel conditions may create fire behavior/events that are outside experiences commonly held by firefighters. What implications does this have for training opportunities in the future?

Keywords: Safety, situational awareness, extreme fire behavior, stories

Bio: Dr. Tamara Wall is an associate research professor at the Desert Research Institute in Reno, NV and the Deputy Director of the Western Regional Climate Center. Additionally, Dr. Wall works with the Center for Climate, Ecosystems, and Fire Applications, and the California-Nevada Climate Applications Program (part of the national NOAA-sponsored Regional Integrated Sciences and Assessments network). Dr. Wall holds a Ph.D. in interdisciplinary studies with an emphasis in hazards geography from The University of Montana. Her work focuses on developing wildfire and climate-related research that can be used in decision making and planning efforts by agencies and organizations.

M17. CAWFE coupled weather-wildland fire model simulations of the October 2017 Northern California Diablo wind event and fires
Presenter: Janice Coen, Project Scientist. NCAR

Several of the most destructive recent wildfire events were associated with strong downslope winds in the lee of mountain ridges, referred to as Diablo winds in northern California. Fires that occur during these events present a hazard to the public and firefighter safety due to their extreme rate of spread and unpredictable aspects, such as their transience and interactions with the coastal atmospheric marine layer.

During the October 2017 wildfires in Napa, Sonoma, and Lake Counties, ignitions and rapid early fire growth appear linked to strong winds in certain mountainous areas that evidence and anecdotal evidence suggests may have reached 30-40 m/s, while surface mesonet data on wind speeds is sparse and unilluminating. Forecasts of the weather leading up to and during these events capture broad spatial patterns of accelerated winds but appear to underestimate a key factor - the peak winds - by 30-50%.

I present convective-scale simulations of the weather leading up to and during this event - simulations that produce extreme winds during the time of fire ignitions - and simulations of the fire growth during early periods of some of the fires using CAWFE's coupled weather-wildland fire modeling capabilities. Briefly, I discuss mechanisms for generating extreme winds that are revealed by microscale modeling and their context in terms of windstorm-driven fires.

Keywords: Diablo winds, windstorm, Napa

Bio: Dr. Janice Coen is a Project Scientist at the National Center for Atmospheric Research in Boulder, Colorado. She received a B.S. in Engineering Physics from Grove City College and an M.S. and Ph.D. from the Department of Geophysical Sciences at the University of Chicago. She investigates wildland fire behavior and its interaction with weather using computational fluid dynamics models and by analyzing infrared imagery of wildland fires. She has served as Associate Editor for the International Journal of Wildland Fire, on the Editorial Board of Environmental Modelling & Software, and on the Board of Directors of IAWF.

M18. Forest disturbance, fuels and flammability in wet eucalypt forests
Presenter: Jane Cawson, Research Fellow. University of Melbourne
Additional Authors: Duff, Thomas, Research Fellow, University of Melbourne
Swan, Matthew, Research Fellow, University of Melbourne
Tolhurst, Kevin, Honorary Associate Professor, University of Melbourne
Penman, Trent, Associate Professor, University of Melbourne

Disturbances can have profound effects on forest structure and composition. These changes also affect fuels, and can consequently alter the flammability of a forest. Understanding these post-disturbance pathways is critical for understanding wildfire risk. We undertook two studies evaluating post-disturbance flammability pathways in tall wet *Eucalyptus* forests in southeastern Australia. Infrequent stand replacing fire is a key feature of the life-cycle of these forests. However, fire that is too frequent (less than 25-30 years) can damage regenerating trees and result in the loss of key species. We examined the effects of three different disturbance types – low and high severity wildfire, and logging – on fuel structure and moisture content. In the first study we measured fuel structure in a chrono-

sequence of 141 sites. We found differences in fuel structure, with surface fine fuel, fuel hazard, species composition and vertical structure differing most between forest age classes and disturbance types. The implications for flammability, however, were less clear as the independent and interactive effects of many fuel components on overall flammability remain unquantified. Importantly, we found very high fuel levels across all disturbance classes, which suggests fire occurrence is not fuel-limited in wet eucalypt forests. In the second study we measured fuel moisture in a chrono-sequence of 8 sites. We found lower moisture contents in sparser canopied forests and higher moisture contents in denser canopied forests. There were large differences in canopy cover between the recently burnt low and high severity forests but for longer unburnt forests (33 years, 77 years and 100+ years) canopy cover did not appear to vary as a function of time since fire, suggesting the effect of disturbance on fuel moisture is short-lived. Together these studies highlight the need for further flammability research in wet eucalypt forests because our understanding of links between fuels and flammability is incomplete. In the absence of further flammability research, our results suggest moisture is a critical determinant of fire occurrence. While moisture contents did not vary substantially as a function of time since disturbance they are likely to be affected by climate change. Lower moisture contents in these forests under climate change could mean the forests burn more frequently; fires occurring at intervals less than 25-30 years would have significant ecological consequences.

Keywords: disturbance; flammability; forest succession; fuels

Bio: Jane is a forest scientist whose research examines bushfire behaviour and management, and its effects on vegetation and soil. Before embarking on her research career she worked in fire and emergency management for the State government of Victoria, Australia.

M19. The effects of an invasive grass, Bothriochloa ischaemum, on fuel loads and fire temperatures

Presenter: Carolyn Whiting, PhD Candidate. University of Texas at Austin
Additional Authors: Behr, Whitney, PhD Student, University of Texas at Austin
Lichtenberg, Elinor, Research Fellow, University of Texas at Austin
Jha, Shalene, Associate Professor, University of Texas at Austin
Fowler, Norma, Professor, University of Texas at Austin

Non-native invasive grasses can have many negative effects on plant communities and the animals that depend on them. These include outcompeting and replacing native species, which can change characteristics of the fire regime, such as fire frequency, season of fire, fire severity, etc. Some of the best-studied examples of a non-native grass changing a fire regime are Bromus tectorum (cheatgrass) in the inter-montane western United States and Cenchrus ciliaris (buffelgrass) in the Sonoran Desert. The effects on fire regimes of the invasive Old World bluestem grasses (Bothriochloa spp., Dicanthium spp.) are not well-understood, but their vigorous growth and persistent upright dead stems suggest that their effects may be substantial. We studied the effects of two varieties of one the most common and wide-spread of these Old World bluestem grass species (Bothriochloa ischaemum var. songarica and B. ischaemum ischaemum) on fire characteristics. Our study had twelve sites, located from central Texas to southern Oklahoma. B. ischaemum var. songarica was common in the southern sites; B. ischaemum var. ischaemum was common in the northern sites. This study was part of a larger study to determine the effects of fires on plant communities, especially on the resources they provide for pollinators. We measured fuel and fire characteristics in multiple plots in each site. We compared fuel properties and fire characteristics, especially fuel load, fuel height, and fire temperature, among sites, between B. ischaemum varieties, and among plots with and without one of the varieties of B. ischaemum. B. ischaemum presence increased fuel loads; sometimes increased fuel height; and had complex effects on

fire temperature that depended on variables such as relative humidity and the water content of the fine fuel. Our results suggest that B. ischaemum can increase the likelihood and severity of fires in many situations, and that the presence of Old World bluestems is likely to affect fire regimes.

Keywords: invasive species, fire regimes

Bio: Carolyn Whiting is a PhD candidate at the University of Texas at Austin. She is interested in the bidirectional relationship between plant ecology and fire regimes. Her dissertation research is focused on how plant communities and populations are affected by fire seasonality. She hopes to be able to identify a time of year to conduct prescribed burns in south central USA that will help control invasive Old World bluestems.

M20. After The Smokes Clears: The Thomas Fire Debris Flow in Montecito California

Presenter: Peter Robichaud, Research Engineer. USDA Forest Service Rocky Mountain Research Station

Severe erosion, debris flows and flooding after wildfires are the secondary factors most visible after the fire itself. The 2017 Thomas Fire was the largest wildfire in the State of California, burning 112,000 ha. A significant rainfall event on 8-9 January 2018 caused severe erosion, debris flow and flooding in four burned watersheds above the community of Montecito, California. The burned area included steep (45-85% slopes) incised canyons above debris fans at the base of the Santa Ynez Mountains. The soil burn severity map indicated the majority of the canyons experienced moderate soil burn severity in chaparral dominated vegetation. Soil char was ubiquitous along with strong water repellency. Post-fire dry ravel abundantly occurred throughout the canyon areas and preloaded channels with sediment. Rainfall began on 8 January 2018 as a low pressure system moved in from the Pacific Ocean. Early in the morning on 9 January, the rainfall peaked with a 15-minute rainfall intensity of 22 mm per hour, equating a 50-year rainfall event. There was a little lag time between the occurrence of this short burst of high-intensity rainfall and the start of the debris flows. The rain-soaked soil responded immediately to the rainfall and surface erosion occurred on almost every slope where the increased flow depth produced high soil shear stress. Within a short distance, rills began to form. Development and expansion of this rill network allowed for rapid flow concentration and movement of water and sediment downslope with bulking of soil within the flow. Stream peak discharges increased 3-fold higher than normal. As the flow continued, it gradually entrained more material such as trees, cobbles, and boulders. The substantive flow moved downstream until the channel gradient lessened and the flow and debris spread out. This singular debris flow destroyed 130 houses, moderately damaged 300 houses, and caused minor damage and flooding to 3000 houses. Because of the timing and intensity of the precipitation, there is little that could have been done differently within established post-fire protocol to prevent such massive-scale erosion. However, the knowledge that such an event is possible should initiate conversation, research and tools to try and prevent a recurrence.

Keywords: Flooding, erosion, rainfall, post-fire

Bio: Pete Robichaud is a Research Engineer with the USDA Forest Service, Rocky Mountain Research Station in Moscow, Idaho. Pete studies and models soil erosion as affected by wildfires. His field research includes plot-scale infiltration, erodibility studies, paired watershed studies and large-scale remote sensing projects. He is an international leader in postfire hydrology effects and monitoring techniques. He leads various research teams, developed the popular web-based probabilistic Erosion Risk Management Tool (ERMiT), and evaluate erosion mitigation treatments. Pete has published over

200 scientific articles, one book, holds two patents and still spends his summers chasing wildfires and playing in the dirt.

M21. Fire Moss: An Under Explored Community and Potential Tool for Restoring the Post Fire Environment

Presenter: Henry Grover, Graduate Student. Northern Arizona University
Additional Authors: Bowker, Matthew, Assistant Professor, Northern Arizona University, School of Forestry
Fule, Peter, Professor, Northern Arizona University, School of Forestry
Doherty, Kyle, Graduate Student, Northern Arizona University, School of Forestry
Antoninka, Anita, Research Associate, Northern Arizona University, School of Forestry
Sieg, Carolyn, Research Plant Ecologist, Rocky Mountain Research Station
Robichaud, Peter, Research Engineer, Rocky Mountain Research Station

With wildfires increasing in extent and severity throughout the Western United States, land managers need new tools to stabilize recently burned ecosystems. Fire mosses consist of three species, Ceratodon purpureus, Funaria hygrometrica, and Bryum argenteum that naturally colonize burned landscapes, can aggregate soils reducing erosion, and can be grown rapidly in the greenhouse. In this talk, I will focus on two aspects of our effort to develop fire moss as a restoration tool. First, we conducted a survey to understand how fire moss naturally interacts with severely burned landscapes and second, we inoculated greenhouse grown fire moss on a recent wildfire in the southwest in a BAER relevant timeline. In the natural survey, we examined 69 plots on 10 fires in Arizona, New Mexico and 21 plots on 4 fires in Washington and Idaho selecting a range of times since fire and stratified plots by winter insolation (the amount of sun an area receives on Dec 21) and elevation. At all plots we measured, vascular plant cover and fire moss cover to species. Moss cover ranged from 0-75% with a mean of 16% and was inversely related to insolation ($R^2 = .32$, $p <.001$) and directly related to elevation ($R^2 = .13$, $p = .02$). Additionally, in the Southwest, we measured a suite of soil characteristics on moss covered and adjacent bare soil including aggregate stability, shear strength, compressional strength, and infiltration rates. Moss covered microsites had twice as much shear strength and compressional strength, and three times higher aggregate stability and infiltration rates as adjacent bare ground.
In the inoculation experiment we added all three species of fire moss to a wildfire that had been fully contained for less than 2 weeks. We manipulated moss addition with levels of sieved moss, moss ground in a mill, and moss combined with diatomaceous earth and rolled into pellets. None of the treatments attained more than minor cover (.5%). However, it is encouraging that many moss colonies were formed on pellet treated plots with a mean of 93 compared to 1.8 for controls ($p <.001$), portending the potential for future high cover. These preliminary results inform where fire moss could naturally increase postfire hillslope soil stability, and locations for targeting fire moss research and restoration efforts. They also suggest that fire moss could be a valuable tool to provide ground cover and mitigate post wildfire erosion.

Keywords: Fire Moss, Burned Area Emergency Response, Post-fire Restoration, Mixed Conifer Forests

Bio: Henry's research interests lie within applied ecology and ecological restoration. As a technician in Moab, Utah the importance of mosses and associated biocrust species to the greater ecosystem drew his attention. Consequentially, he is intrigued by the idea of returning functionality to some of our most degraded landscapes using these often-overlooked ecosystem engineers. Restoration ecology is the confluence of many disciplines including engineering, sociology, economics, and ecology and Henry enjoys being a generalist who considers many fields of thought when developing new techniques for land management that are based in science and practically feasible.

M22. Integrated Fire Management, Developments in Indonesia
Presenter: Brett Shields, Director. Spatial Informatics Group
Additional Authors: Jose Duce, The Nature Conservancy TREX program & Juan Caamano, Pau Costa Foundation, Spain

Indonesia is not often considered a fire prone environment, and in prehistory it was not. It's a tropical environment and the worlds largest area of tropical peatlands (which can only form over thousands of years in the absence of fire). Fire dates back to human habitation on the islands and large scale fire correlates with the introduction of industrial agriculture and forestry which expanded heavily in the 1970's through to today.
Indonesia's peatlands account for approximately 2.5% to total global carbon emissions, and approximately 95% of this is the result of burning peatlands. The smoke haze from one fire episode is estimated to have caused in-utero and infant mortality rates to increase by 15,000 deaths. There are no natural fire causes in Indonesia, humans are the source of ignition for all manner of needs including: livelihood sustainability, conflict resolution, agricultural planting and more. The implications and impacts of these fires on rural families working to live, and large companies building larger conglomerates is challenging to appreciate.
SIG has worked in Indonesia since 1999 and presently on a longer basis with the largest industrial forestry company across 2.6 million hectares (6.4 million acres). We have partnered with groups and individuals to undertake this work and include trainers from The Nature Conservancy TREX program, operational staff from the Pau Costa Foundation in Spain, and PhD students working on community based fire prevention.
We will present to you some of the accomplishments the group has collaborated towards, as well as the challenges of the past and present fire environment. We will discuss the challenges of international fire consulting practices of the past which has created the problems of today, and we'll discuss the processes and practices of Integrated Fire Management (IFM) which is turning around the situation in Indonesia.
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Keywords: Integrated Fire Management, Indonesia

Bio: Brett leads the Asia Pacific Team at SIG. Brett is an experienced international manager with a leading reputation in the field of fire risk analysis and community based fire management (CBFiM) and works primarily across Asia, the Pacific and Australia. Brett is one of the foundation authors of Community Based Fire Management as well as Integrated Fire Management (IFM), sometimes known as the 5R's. Brett's work focusses on fire management for public and private good and has consulted across tropical, temperate and boreal environments.

Micro-Talk Abstracts