## 1. Regional likelihood of very large wildfires over the 21st century across the western United States

***Presenter:*** *Stavros, PhD, E. Natasha, Post-Doctoral Research Scientist, Jet Propulsion Laboratory*
***Additional Author(s):***
*John Abatzoglou*
*Narasimhan K. Larkin*
*Donald McKenzie*
*E. Ashley Steel*

Studies project that a warming climate will likely increase wildfire activity. These analyses, however, are of aggregate statistics of annual area burned, which inhibit analyzing changes in seasonality of fire events. This investigation shows that very large wildfires (>20,234 ha ~50,000 ac) may only account for the top two percent of all fires burned in the western contiguous United States, but they constitute a substantial fraction (approximately 33 percent) of aggregate area burned from 1984 to 2010. Using composite records of climate and fire, we investigate the spatial and temporal variability of the very large wildfire climate space. Both qualitative and quantitative (logistic regression models with strong accuracy of area under the curve (AUC) > 0.80) assessments of this climate space show that these fires may drive broad-scale wildfire area burned relationships to climate.

Using the developed quantitative models, we project how the likelihood of very large wildfires will change regionally across the western United States using two representative concentration pathways (RCPs) 4.5 and 8.5. Results show a significant ($p \leq 0.05$) difference between the historical modeled ensemble mean probability of a very large wildfire occurrence from 1979 to 2010 and both RCP 4.5 and 8.5 means during 2031 to 2060. Generally, there are higher probabilities of very large wildfire occurrence both more frequently and for longer periods throughout the fire season, with more pronounced patterns under RCP 8.5 than RCP 4.5. Furthermore, the frequency of very large wildfire occurrence significantly increases in all regions, but particularly in regions that currently have a flammability or mixed flammability-fuel limited fire regime. Our results provide a quantitative foundation for investigating and developing management strategies to mitigate the effects of a changing wildfire environment, one marked by longer fire seasons with more very large wildfires.

**Keywords:** climate change; large wildfire; likelihood;

**Bio:** Natasha is a post-doc at Jet Propulsion Laboratory working in Climate Sciences on the Carbon Initiative to synthesize and connect carbon related remote sensing projects, specifically related to terrestrial productivity at high latitudes and across the Rim Fire, Yosemite National Park, Ca. She has a background in mathematics, computer science, and fire ecology.

## 2. Monitoring large fire susceptibility in Washington, Oregon, and California using MODIS

***Presenter:*** *Yang, Zhiqiang*
***Additional Author(s):***
*Davis, Raymond, Northern Spotted Owl Monitoring Module Leader, USDA Forest ServiceFS*
*Cohen, Warren, Research Forester, USDA Forest Service*

Mapping fire prone area, especially large fire in forest has significant implications for forest management as well as wild life conservation. In this study, we presented a framework of modeling large fire probability in forested area of the Washington, Oregon, and California. The analysis uses environmental gradient, forest successional status, and current forest conditions to map the pattern of large fire occurrence. In addition to static environmental variables, e.g. Elevation, slope, radiation etc., parameters derived from 8-day MODIS products e.g. land surface temperature and vegetation indices were used as the predictor. It is hypothesized that stressed forest is more prone for fire, which is manifested through vegetation indices and land surface temperature. In this analysis, random samples historical fire from 2002 to 2010 (MTBS) were used as training data and fire from 2011 to 2013 were used for model validation. The resulting model was implemented to monitoring large fire susceptibility as new MODIS products are available.

**Keywords:** fire susceptibility, MODIS

**Bio:** research associate in Department of Forest Ecosystem and Society, Oregon State University.

**3. Analysis of Three Large Fires that Occurred in Portugal in 2012 and 2013**

***Presenter:*** *Viegas, Prof., Domingos, Professor, ADAI, University of Coimbra*
***Additional Author(s):***
*Viegas, Domingos, PhD, Professor, ADAI, University of Coimbra, Portugal*
*Almeida,Miguel, PhD, Researcher, ADAI, University of Coimbra, Portugal*
*Ribeiro, Luis, Researcher, ADAI, University of Coimbra, Portugal*
*Gabbert, Bill, Sagacity Wildfire Services, USA*

Three large forest fires that occurred in 2012 and in 2013 in Portugal: the fire of Tavira with 24 843 hectares burned, the fire of Alfândega da Fé, with 13,706 hectares and the fires of Caramulo with 9,416 are analyzed.

The Portuguese Government requested to ADAI a report about these fires in order to assess the situation and to improve the organization of the fire management system.
The fire of Tavira was initiated in July 18th and spread very rapidly due to very severe fire danger conditions. The presence of several houses and settlements and the very complex orography complicated the organization of fire suppression during the initial hours of the fireSome reinforcements were dispersed to other two new fires coinciding with strong winds that caused very rapid fire spread of the Tavira fire that burned more than 10,000 hectares in less than four hours endangering hundreds of houses. Some difficulties found with the management of this fire were reported and measures to improve the capacity of the system to manage such large fires and to reduce their impact in future situations were taken.

The fire of Alfândega started on 8th July 2013 and was controlled after several hours having reached an area of 180 hectares. On the following day the fire rekindled and with westerly winds above 50 km/h spread out of control for 15 km in six hours. In its path the fire overran a village endangering its population. On the 11th July a wind change pushed part of the southern flank of the fire creating great problems to the protection of other two settlements.

The fires of Caramulo were the result of three independent fires that spread in the mountain of Caramulo. The first two started in the night of 20th August in the same area but spread in practically opposite directions. On the 22nd a very bad accident occurred in the flank of Silvares fire. During a downhill attack the fire erupted and endangered a group of 20 firefighters that escaped to a safety zone. Unfortunately two of them were injured to death by the fire. On the 29th in another section of the same fire another accident caused the death of two fire fighters. In the 28th a third fire was started by accident and due to very strong Eastern winds during the night it spread very rapidly to the West over-running around 6,000 hectares in 4 hours. Besides the loss of lives, these fires were characterized by very difficult fire suppression conditions due to high values of fuel load very low humidity, complex topography and episodes of strong and erratic winds.

**Keywords:** Large Fires, Fire spread, Fire assessment, Safety

**Bio:** Full Professor at the Department of Mechanical Engineering of the Faculty of Science and Technology of the University of Coimbra, in Portugal.
Head of the Centre for Forest Fire Research (CEIF) since 1986.
Developed research activity in the fields of fire propagation and fire safety.
Coordinated several National and European research projects in this field.
Author of many publications and Lecturer at international meetings on the topic of forest fires.
He promoted six International Conferences on Fire Science, and many other Seminars and training courses about forest fires.

**4. Exploring the drivers of extreme wildfire development**

***Presenter:*** *Sharples, Jason, UNSW Australia*
***Additional Author(s):***
*Rick McRae, ACT Emergency Services Agency*
*Mike Fromm, U.S. Naval Research Laboratory*

Extreme wildfires are global phenomena that consistently result in loss of life and property, and further impact the cultural, economic and political stability of communities. In their most extreme form they cause widespread devastation of environmental assets and are capable of impacting upper atmospheric conditions. This paper considers a number of notable Australian wildfires that are known to have generated significant pyrocumulonimbus clouds in a series of blow-up events. Observations of these fires are analysed to investigate the localised processes contributing to extreme fire development. In particular, it is demonstrated that the most extreme instances of pyroconvection were driven by the fire channelling phenomenon, which arises due to an interaction between an active fire, local terrain attributes and critical fire weather, and causes the fire to rapidly transition from a frontal to an areal burning pattern. The impacts of local variations in fire weather and of the atmospheric profile are also discussed, and the ability to predict extreme fire development with state-of-the-art tools is explored.

**Bio:** Jason is Senior Lecturer and part of the Applied and Industrial Mathematics Research Group at the School of Physical, Environmental and Mathematical Sciences, University of New South Wales. His research covers the topics of extreme wildfire dynamics and complex combustion process.

**5. Historical fire climatology and large fires in Victoria**

***Presenter:*** *Gellie, Nicholas, Fire scientist, Ecofuego*

Victoria placed in the south-eastern corner of Australia has a fire environment that from time to time has the critical combination of droughts, heat-waves, extreme fire weather, and fire ignitions to create and drive large bushfires. This paper examines the history of large bushfires since European settlement (Black Thursday 1851, Black Tuesday 1898, Black Friday 1939, the 2003 Alpine fire, the 2007 Great Divide, the 1983 Ash Wednesday, and the Black Saturday 2009 fires) together with their seasonal climatic, ignition, and fire weather drivers.

The seasonal climatic conditions for the last 160 years were recreated using a daily soil water balance model based on daily evaporation and rainfall. Historical fire weather records were assembled from either daily newspapers or Bureau of Meteorology reports or from 3-h or daily 1500-h weather data. Fuel moistures were estimated using equilibrium fuel moisture equations based on ambient temperature and relative humidity. The FFDI and Canadian FWI were calculated based on the available fire weather data. Geographic location and cause of more recent fires were based on Department of Environment and Primary Industries (DEPI) ignition datasets and newspaper records. Synoptic maps for the sequence of days leading up to and including the blow-up days were also analysed to determine the air mass conditions producing the fire environment conditions.

My results show that most of the significant large bushfires historically have occurred when below average rainfall in the spring and summer months are combined with heat wave conditions in the January-February peak summer period. Continental heat troughs over central Australia interacting with cool maritime cold fronts associated with low pressure systems in the southern Australian Bight are the major driver of the hot, dry, and windy weather conditions in all major large destructive fires. Typically, large bushfires can exceed 25,000-100,000 ha in 3-8 h from a single ignition. Not all large fires are driven by a single day severe fire weather event but by less severe recurring days.

The last 10-15 years have seen an increase in the number of heat-wave days in a dry fire season that can turn a moist forest landscape into a dry one within a month, creating the seasonal fuel moisture conditions for large landscape fires. Prior to this this could have taken more than 2-3 months. This heralds a new era for heat-wave driven fires seasons that are now occurring more frequently every 2-3 years instead of every 5-20 years.

**Keywords:** Fire climatology, heat-waves, large landscape fires

**Bio:** Nic graduated from the Australian National University with a BSc.(Forestry) and a MPhil on regional fire climatology. In the last 35 years he has been a fire researcher, vegetation and fire ecologist, fire manager, fire consultant, and conservation planner in his career. He lives in Mansfield in north-eastern Victoria where he conducts independent fire research on bushfires in south-eastern Australia. Besides bushfire research, His interests are bushwalking, cycling, sailing, watercolour art, sustainable living, solar passive houses and being with his family.

He has conducted research on the spread and dynamics of bushfires, including pyro-convection. He is currently investigating fuel moisture relationships to fire intensity and energy release in bushfires.

**6. Using the Evaporative Demand Drought Index and the Palmer Drought Severity Index to Forecast the Number of Large Wildland Fires on Federal Lands**

***Presenter:*** *Ham, PhD, Charlotte, Postdoctoral Economist, North Carolina State University*
***Additional Author(s):***
*Hobbins, Mike, Visiting Scientist, NOAA-National Integrated Drought Information System*
*Abt, Karen, Research Economist, US Forest Service, Southern Research Station*
*Prestemon, Jeff, Research Forester, US Forest Service, Southern Research Station*

Fire modelers have traditionally used the Palmer Drought Severity Index (PDSI) to represent local soil and vegetative moisture when forecasting fire, as well as to predict fire-suppression expenditures, due largely to the availability and simplicity of forcing data (precipitation and temperature). However, researchers are questioning the appropriateness of the index in regions outside the northern continental interior where temperature is not the primary driver of actual evapotranspiration. Rather, an alternative measure, the Evaporative Demand Drought Index (EDDI) that includes the effects of multiple drivers may provide more accurate forecasting ability. The EDDI is derived from a measure of atmospheric evaporative demand from the American Society of Civil Engineers Standardized Reference Evapotranspiration equation including six North American Land Data Assimilation System variables (temperature, specific humidity, station pressure, wind speed, and downwelling shortwave radiation). Here, we compare forecasts of large wildland fires (size G class) on federal lands for the conterminous United States at various spatial scales using the PDSI to those using the EDDI. Results will be used to improve forecasts of wildland fire suppression expenditures for the U.S. Department of Agriculture Forest Service and the U.S. Department of the Interior.

**Keywords:** forecasting, large fires, suppression costs

**Bio:** Charlotte Ham is a Postdoctoral Scholar/Economist with the Department of Forestry and Environmental Resources at North Carolina State University. She is collaborating with the USDA Forest Service Forest Economics and Policy Research Unit at the Southern Research Station to improve wildland fire suppression cost forecasts for the USDA Forest Service and the Department of the Interior. Her doctorate is from Colorado State University's Graduate Degree Program in Ecology through an interdisciplinary program in Resource Economics. Her dissertation is a geospatial exploration of how people value properties in close proximity to different land uses for consideration in planning and policy analysis.

**7. Mixed-Severity Fire in Lodgepole-Dominated Forests: Are Historical Regimes Sustainable on Oregon's Pumice Plateau, USA?**

***Presenter:*** *Loehman, PhD, Rachel, Research Ecologist, USFS Rocky Mountain Research Station, Fire Lab*
***Additional Author(s):***
*Heyerdahl, Emily, PhD, Research Forester, USFS Rocky Mountain Research Station, Fire Lab*
*Falk, Don, PhD, Associate Professor, School of Natural Resources and the Environment, University of Arizona*

In parts of central Oregon, coarse-textured pumice substrates limit forest composition to low-density lodgepole pine (Pinus contorta Douglas ex Loudon var. latifolia Engelm. ex S. Watson) with scattered ponderosa pine (Pinus ponderosa Lawson & C. Lawson) and a shrub understory dominated by antelope bitterbrush (Purshia tridentata (Pursh) DC.). We reconstructed the historical fire regime from tree rings and simulated fire behavior over 783 hectares of this forest type. For centuries (1650-1900), extensive mixed-severity fires occurred every 26 to 82 years, creating a multi-aged forest and shrub mosaic. Simulation modeling suggests shrub biomass and wind speed were the primary drivers of this historical mix of surface and passive crown fire. However, a century of fire exclusion has reduced the potential for the high-severity patches of fire that were common historically, likely by reducing bitterbrush cover, the primary ladder fuel. This reduced shrub cover is likely to persist until fire or insects create new canopy gaps. If the climate predicted for mid-century lowers fuel moistures, crown fire potential may increase even with current fuel loadings, but only under rare extreme winds. This study expands our emerging understanding of complexity in the disturbance dynamics of lodgepole pine across its broad North American range.

**Keywords:** fire history, climate, fire behavior, Oregon, lodgepole, bitterbrush

**Bio:** Rachel A. Loehman is a Research Ecologist with the US Forest Service Rocky Mountain Research Station, Fire Sciences Lab in Missoula, MT. Her research focuses on understanding complex, multi-scale ecological dynamics in natural and coupled human-natural systems, including climate change impacts, short- and long-term landscape responses to disturbance processes (e.g., wildfire, insects), disturbance synergies, and critical thresholds. This research is implemented using a combination of field studies, simulation modeling, and spatial and statistical analysis and visualization. Applications include development of strategies for restoration of forests and fire regimes and assessments of landscape resilience and vulnerability.

### 8. Structure, Process, and Resilience in Colorado Front Range Montane Forests

***Presenter:*** *Gannon, Benjamin, Research Associate, Colorado Forest Restoration Institute, Colorado State University, Fort Collins CO*

***Additional Author(s):***
*Brown, Peter, Director, Rocky Mountain Tree-Ring Research, Fort Collins CO*
*Battaglia, Michael, Research Forester, USDA Forest Service, Rocky Mountain Research Station, Fort Collins CO*
*Fornwalt, Paula, Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, Fort Collins CO*
*Huckaby, Laurie, Ecologist, USDA Forest Service, Rocky Mountain Research Station, Fort Collins CO*
*Dickinson, Yvette, Assistant Professor, Forest and Rangeland Stewardship, Colorado State University, Fort Collins CO*
*Cheng, Antony, Professor/Director, Colorado Forest Restoration Institute, Colorado State University, Fort Collins CO*
*Julian, Chad, Senior Forester, Boulder County Parks and Open Space, Longmont CO*

Concerns about the resilience of ponderosa pine dominated montane forests of the Colorado Front Range in the face of recent large and uncharacteristically severe wildfires, an extensive bark beetle outbreak, and climate change have led to increased implementation of landscape-scale ecological restoration efforts. These efforts include both structural restoration to recover natural stand conditions and landscape mosaics, and process restoration through increased use of prescribed and characteristic wildland fires. We describe a current project to develop models of historical patterns and processes using tree-ring based reconstructions that is intended to inform restoration efforts. This project, the Front Range Forest Reconstruction Network, collected data from 188 0.5 ha plots both to develop stand and landscape metrics (including historical – ca. 1860 - species composition and diversity; tree densities, basal areas, size and age distributions; and stand to landscape spatial arrangements of trees and openings) and to examine changes in forest conditions and fire regimes across spatial environmental gradients and temporal climatic variation. Results document somewhat predictable environmental and climate variability across gradients present in Front Range montane forests. Models have been developed that provide both direction and justification for ecological restoration intended to restore resilience across montane ecosystems.

**Keywords:** Fire Ecology, Historical Reconstructions, Dendrochronology, Forest Restoration

**Bio:** Ben completed his MS in Ecology at Colorado State University where he worked in the Landscape Ecology Lab studying the impacts of hurricanes on tropical montane forests. He has a background in forest ecology, forest inventory, GIS, remote sensing, and spatial modeling. He is currently a research associate with the Colorado Forest Restoration Institute where he runs the Front Range Forest Reconstruction Network alongside many collaborators. His interests include fire ecology and fire history, especially the interplay between patterns and processes at stand-to-landscape scales.

### 9. Are Gullies Refuges For Birds? The Value Of Topographical Heterogeneity To Avifauna Within A Fire-Prone Landscape

***Presenter:*** *Robinson, Natasha, Fire ecology project officer, Department of Environment and Primary Industries, State Government of Victoria*
***Additional Author(s):***
*Leonard, Steve, Research Fellow, La Trobe University*
*Bennett, Andrew, Associate Head of School (Research), Deakin University*
*Clarke, Michael, Head of School of Life Sciences, La Trobe University*

Unburnt areas that remain within mega-fires are important faunal refuges, maintaining fire sensitive species within the fire boundary. However, due to the scarcity of such residual vegetation, mega-fires are sometimes perceived as homogenising detrimental ecological events. Uniformity in fire spread may be moderated by topographical relief such that sheltered areas (e.g. gullies) escape fire. As such, gullies are considered to be natural and deterministic faunal refuges in fire-prone landscapes. Gullies, however, are not immune to fire and, under extreme fire weather conditions, can burn. This may compromise their habitat value, and diminish differences in faunal communities across topographical gradients. We investigated the extent to which topographical differences in avian communities were maintained when subjected to uniform fire severity and fire history across the gully and slope components of a site. We predicted that differences in bird communities between gullies and slopes would decline under increasing severity or long periods when both gullies and slopes remained unburnt. Bird surveys were conducted in 91 paired gully/slope sites two to three years after a large, severe wildfire (> 200,000 ha) in eucalypt forest of the Victorian Central Highlands, south-eastern Australia. Sites were selected according to four levels of fire severity (unburnt through to crown burnt) and two levels of fire history prior to the wildfire (< 3 years, > 20 years). Under similar conditions of fire severity and fire history, gullies maintained greater bird richness and abundance than slopes, along with a distinct bird assemblage to slopes. However, contrary to our predictions, topographical differences for most avian responses did not diminish with increasing severity or in the long absence of fire. Our findings highlight the importance of gullies as natural topographic refuges, even when burnt. Nonetheless, unburnt gullies provide essential habitat for late successional specialists and management should continue to protect their structural integrity from actions that threaten these values for fauna. We further suggest that management seeking to use planned fire to generate heterogeneity and enhance biodiversity (e.g. mosaic burning) may get better return-for-effort in flat landscapes, where heterogeneity is less likely to be achieved under uniform fire conditions than in topographically diverse landscapes.

**Keywords:** biological legacies, unburnt patches, residuals, mega-fire

**Bio:** Natasha Robinson is a PhD candidate at La Trobe University investigating the importance of residual habitat within burnt landscapes to birds. This research has addressed questions concerning the relevance of fire severity, fire history, topography, habitat elements and spatial properties of residual habitat within a large, intense wildfire. Natasha has long held an interest in fire ecology and has been fortunate enough to have worked in many diverse ecosystems in eastern Australia and northern Vietnam. She has recently resumed working as a fire ecologist for the Department of Environment and Primary Industries, State Government of Victoria.

**10. Disturbance and maintenance of aspen ecosystems**

***Presenter:*** *Krasnow, PhD, Kevin, Graduate and Research Faculty, Conservation Research Center of the Teton Science Schools*
***Additional Author(s):***
*Stephens, Scott, Professor of Fire Science, University of California Berkeley*

Disturbance and maintenance of aspen ecosystems
A warming climate will likely increase the frequency, size and severity of wildfires in the western United States. These disturbances are expected to play a role in mediating the speed and likelihood of species' migrations and may be an important ecological filter controlling community composition in the coming century. This talk will explore how the projected increase in fire severity and spatial extent will impact aspen (Populus tremuloides) population dynamics, and explores how adaptive management can maintain existing aspen populations and facilitate migration to accommodate climate change. Aspen is considered a foundation species and adds significant biological diversity to conifer-dominated western forests, yet represents a small fraction of forest cover in the American West. Aspen are also particularly sensitive to climate, and are currently a species of concern due to wide-scale, drought-induced mortality and successional replacement in the Intermountain West.
This research integrates strategies of resistance, resilience, and response to inform future management decisions for this foundation species. Experimental questions include:
-Resistance Strategies: How do aspen stands respond to prescribed fire and conifer removal restoration treatments? How do these simulated disturbances compare to unplanned wildfires?
-Resilience strategies: How does stand composition and fire severity impact post-fire aspen response?

-Response strategies: Is it likely that aspen will be able to successfully migrate via seed? What role will fire play in aspen migration? What forms of human assisted migration may be viable to establish new stands?

Data from four wildfires, three prescribed fires, and four conifer removal sites in the Sierra Nevada show that both conifer removal and prescribed fire can be effective restoration treatments but that unplanned wildfire produces significantly higher ramet density than either treatment. A significant negative relationship was found between pre-wildfire conifer basal area and post-fire aspen ramet density, indicating that conifer encroachment negatively impacts aspen resilience to fire. Additionally, a significant positive relationship was found between fire severity and post-fire aspen ramet density and growth rates, indicating that increased disturbance severity favors aspen regeneration and persistence. The likelihood and success of aspen migration via sexual reproduction and human assisted migration will also be discussed.

**Keywords:** aspen, fire severity, Sierra Nevada, restoration, migration

**Bio:** Kevin examines how human management, climate change, or natural disturbances such as wildfire impact habitat quality, species diversity, wildlife movement, and broader ecosystem services. Field observations provide the foundation of his research, but he also employs simulation models, experimental manipulations, remotely sensed data, and geospatial analysis. He works at a variety of spatial and temporal scales to elucidate how ecosystems have functioned historically and to predict likely trajectories in the future. He works as a research ecologist and graduate program faculty at the Teton Science Schools in Jackson, Wyoming.

### 11. Ten Years Of Understory Vegetation Assembly Following Colorado's Largest Mega-fire

***Presenter:*** *Fornwalt, Paula, Research Ecologist, USDA Forest Service, Rocky Mountain Research Station*
***Additional Author(s):***
*Abella, Scott, Director and Ecologist, Natural Resource Conservation LLC*

Elevated fuel loadings and climate change are transforming fire regimes in many coniferous ecosystems, and post-fire understory vegetation development frequently remains unpredictable. Using a unique set of pre-fire and post-fire data, combined with data collected in nearby unburned areas, we examined 10 years of understory vegetation assembly after the 2002 Hayman Fire, the largest in recorded history in Colorado, USA. Data within the Hayman Fire were collected 5 to 6 years pre-fire, and 1, 2, 3, 4, 5, and 10 years post-fire. Data in unburned areas were collected 2, 3, 4, and 10 years after the Hayman Fire. The resilience of the understory community (i.e., the ability of the understory community to return to pre-fire composition after a decade of recovery) declined with increasing fire severity. However, >60% of 'legacy' species (species present in the pre-fire community) were present in post-fire plots, even in severely burned areas, and these patterns of resilience appear to be driven by newly colonizing species. Perseverance of legacy species, coupled with new colonizers, created a persistent increase in species richness relative to pre-fire levels. This increase in richness was primarily the result of a first-year increase (maintained over time) in forbs with short life spans and a delayed surge in long-lived forbs beginning in post-fire year 3 (maintained over time). Burning tended to increase exotic plant richness and cover relative to pre-fire and unburned areas, but native species always comprised >89% of total richness and cover. This study informs debate in the literature about whether these increasingly large fires are 'ecological catastrophes.' While many view the Hayman Fire as largely catastrophic, especially from an overstory tree perspective, from an understory perspective, burning promoted rich and productive native understories despite the entire 10-year post-fire period receiving below-average precipitation.

**Bio:** Paula Fornwalt got her BS in Environmental Science from the University of Delaware in 1996, her MS in Forestry from Colorado State University in 1999, and her PhD in Ecology from Colorado State University in 2009. She currently works as a Research Ecologist for US Forest Service's Rocky Mountain Research Station in Fort Collins, Colorado. Her research examines how natural and human disturbances impact plant populations and communities in Rocky Mountain forests. She is currently working on projects that explore the consequences of ongoing insect and disease epidemics, wildfire, and forest management practices on forest understories and overstories.

**12. Restoring oak woodlands in fire-excluded landscapes: Lessons from large wildfires in northern California**

***Presenter:*** *Varner, PhD, Morgan, Assistant Professor, Mississippi State University*
***Additional Author(s):***
*Cocking, Matthews, Forester, USDA Forest Service Natural Resource Conservation District*

Landscape-level fire exclusion and other changes have precipitated widespread native conifer encroachment into formerly open Oregon white (Quercus garryana) and California black (Q. kelloggii) oak woodlands and savannas throughout northern California. The native conifers Douglas-fir (Pseudotsuga menziesii) and white fir (Abies concolor) are primary encroachers, decreasing understory plant diversity and altering fuels substantially. Prescribed fire treatments have been used at small scales to halt conifer encroachment and maintain oak dominance, but substantial hurdles impede landscape-scale restoration and the effectiveness of prescribed fire in these important plant communities. We studied two large wildfires in northern California to evaluate effects of differential fire severity in encroached Q. kelloggii -conifer forests in the Klamath and Cascade Ranges. Sites shared a pattern of high severity fire coincident with oak persistence (re-sprouting), and low severity fire with fir resilience (high survival) in combination with some oak mortality (5-9%). At the Klamath site, moderate to high severity fire (>75% stem mortality) resulted in a strong oak resprout response (84% of killed stems) while encroaching conifers suffered very high mortality (mean 95%). At the Cascades site, sprouts in areas of complete overstory mortality (100%) developed into large (3 to 6 m tall), dense sprout clumps 10 years following fire. Using additional findings from studies of prescribed fire effects in nearby, similar oak-conifer forests, we build on a conceptual model of fire disturbance mechanisms for ecosystem transition, and present parallels between this pattern and theories of alternative stable states. Our findings offer insight into how fire can catalyze ecosystem transition and help maintain or stabilize species composition for one forest type in northern California. With the addition of a conceptual transition model, we draw attention to how re-introduction of low-severity fires (e.g., the majority of prescribed fires) could produce limited or undesired results, and propose the potential applicability of this model in other landscapes where fire exclusion has caused significant vegetation type transformation.

**Keywords:** resprouting, conifer encroachment, post-fire mortality, prescribed fire, wildfire

**Bio:** J. Morgan Varner is Assistant Professor of Forestry at Mississippi State University, where he teaches and leads research focused on fire behavior, ecology, and management. He received a Ph.D. from the University of Florida and holds a M.S. from Auburn University and a B.S. from the University of Idaho. He serves on the Editorial Boards of the journals Forest Science and Fire Ecology. He is active in prescribed fire policy via involvement as Chair of the Coalition of Prescribed Fire Councils and on the boards of the Northern California Prescribed Fire Council and Mississippi Prescribed Fire Council.

### 13. Post-fire Logging Effects on Woody Fuels and Potential Fire Behavior up to Four Decades After Wildfire

***Presenter:*** *Peterson, PhD, David, Research Forester, U.S. Forest Service, Pacific Northwest Research Station*
***Additional Author(s):***
*Dodson, Erich, Faculty Research Assistant, Oregon State University*
*Harrod, Richy, Deputy Forest Fire Management Officer, Okanogan-Wenatchee NF*

High severity wildfires create pulses of dead trees that deposit woody fuels as they decay, thereby influencing future fuel loadings and potential fire behavior and effects. Harvesting these fire-killed trees may reduce future woody fuels and related fire hazards, but post-fire logging effects on woody fuels and potential fire behavior and effects have not been fully assessed. To assess post-fire logging effects on woody fuels over time, we sampled woody fuels within 255 coniferous forest stands that burned in 68 high severity wildfires between 1970 and 2007, including 96 stands that were logged after wildfire and 159 stands that were not logged. In unlogged stands, woody fuels were low in recently burned stands, but then increased with increasing time since fire and peaked 10-30 years following wildfire. In logged stands, woody fuels were generally highest in recently burned and logged stands and declined or remained steady with increasing time since fire. Relative to unlogged stands, post-fire logging produced a short-term pulse of elevated woody fuels that lasted about five years, followed by more than 30 years of reduced woody fuels. Post-fire logging reduced large diameter fuels by 60-90% and small diameter fuels by 45-59% between 10 and 35 years after wildfire. Logging also reduced medium diameter fuels by about 30% between 10 and 20 years after wildfire and reduced large rotten fuels by 47-90% between 23 and 39 years after wildfire. Using fire models, we assess the potential impacts of these woody fuel reductions on potential fire behavior and effects for a representative set of fuel models. Our study shows that post-fire logging can significantly reduce future surface woody fuel loadings in forests regenerating following wildfires, and that reductions in woody fuels can influence potential fire behavior and effects. The magnitude of woody fuel reduction depends, however, on the volume and sizes of wood removed, logging methods, post-logging fuel treatments, and the amount of coarse woody debris left on-site to support wildlife habitat, erosion control, and other competing management objectives.

**Keywords:** post-fire logging, fuel dynamics, fuel succession

**Bio:** Dave Peterson is a Research Forester with the U.S. Forest Service, Pacific Northwest Research Station in Wenatchee, Washington. Dave's research focuses primarily on restoration and management of dry coniferous forests of the interior Pacific Northwest, with emphases on forest ecosystem responses to high severity wildfires, effects of post-fire management practices, and vegetation responses to fuels management treatments. He also maintains ongoing research interests in forest vegetation responses to climatic variability and oak savanna ecology.

### 14. Post-wildfire Management in Mixed-severity Wildfire Scars of Black Hills Ponderosa Pine Forests

***Presenter:*** *Battaglia,PhD, Mike, Research Forester, USFS Rocky Mountain Research Station*
***Additional Author(s):***
*Wudtke, Ben, Research Associate, Colorado Forest Restoration Institute*
*Smith, Frederick, Professor, Colorado State University*
*Asherin, Lance, Forester, USFS Rocky Mountain Research Station*

Fire exclusion in ponderosa pine forests has contributed to dense forests and more severe wildfires. This was the case in 2000, when the 34,000 ha Jasper wildfire burned through a ponderosa pine dominated forest creating a mosaic of burn severities. High mortality areas produced heavy coarse woody debris (CWD) loads. Doing fuel reduction treatments to remove heavy CWD loads with prescribed fire has been proposed to decrease possible future wildfire severity. However, understanding the ecological tradeoffs of reducing CWD and killing tree regeneration is needed. Similar questions arise when implementing prescribed fire in moderate mortality areas, which have overstory tree density within desired conditions but have surface fuel loads and regeneration densities above the desired condition. To test the effects of using prescribed burning to reduce CWD, an aerial ignition prescribed burn was implemented 11 years post-wildfire on 688 ha within moderate to high severity areas of the Jasper fire. In high severity areas, pre-burn CWD loads ranged from 0 to 123 Mg/ha, with an average of 56 Mg/ha. Post-prescribed burn, CWD loads ranged from 0 to 67 Mg/ha, with an average of 20 Mg/ha. Pre-burn ponderosa pine regeneration in the high severity was found on at least 50% of plots measured with densities that ranged between 0 to 9883 tph and averaged 1287 tph. Post-burn regeneration was found on 12% of measured plots and averaged 14 tph. In moderate severity areas, pre-burn CWD loads ranged from 0 to 78 Mg/ha and averaged 16 Mg/ha. Post-prescribed burn, CWD loads ranged from 0 to 33 Mg/ha and averaged 8 Mg/ha. Pre-burn ponderosa pine regeneration in the moderate severity was found on at least 60% of measured plots. Densities ranged between 0 to 9883 tph and averaged 420 tph. Post-burn regeneration was found on 25% of measured plots and averaged 137 tph. No significant overstory mortality was observed. Resource objectives to reduce the fuel loads and continuity were met in both severity areas. However, substantial tree seedling mortality occurred in both moderate and high severity burn areas. Also, noxious weeds were commonly observed in the footprint of burned logs in high severity burn areas. Longer-term monitoring of tree recruitment and growth, understory plant recovery, fuel loads, and fire hazard is needed to assess if prescribed fire into these areas produces the desired conditions.

**Keywords:** prescribed fire, CWD, ponderosa pine, reburn

**Bio:** Mike is a Research Forester at the USFS Rocky Mountain Research Station In Fort Collins, CO. His research focuses on developing and implementing innovative management strategies that address the challenges and issues faced by forest managers. These research interests include forest restoration, fuel hazard mitigation, and increasing forest resilience to disturbance.

### 15. Forest Fires, Climate Change and Community Based Fire Management in Bolivia

***Presenter:*** *Ibarnegaray, Veronica, Project manager, Fundacion Amigos de la Naturaleza (FAN)*
***Additional Author(s):***
*Pinto, Carlos, Fire Management expert, Fundacion Amigos de la Naturaleza (FAN)*

Bolivia is one of the most biologically diverse countries in the world, with nearly half of its territory covered by forest. Yet, in the last decade, forest fires have become a major threat to biodiversity and human livelihoods. Fires have burned around 24.5 million hectares of forest and grassland over the past 13 years, showing an increasing trend in burned area and a cyclical pattern of extreme fire seasons which occur every two to three years with devastating consequences for the entire country.
The main causes of forest fires in Bolivia are related to human activities, such as traditional slash-and-burn agriculture, grassland burning for livestock management and the burning of piled biomass from mechanized agriculture. Climate change adds to these threats, with warmer and drier conditions that increase the risk of forest fires.

Facing this situation, Fundación Amigos de la Naturaleza (FAN) works together with local authorities since 2011 on a pilot initiative of community-based fire management and climate change adaptation around protected areas in the Chiquitano Dry Forest ecoregion in the department of Santa Cruz. This initiative is currently being replicated in the Northern Bolivian Amazon region in the department of Beni. These initiatives have increased the level of participation and coordination among local communities to address forest fires and climate change through the establishment of inter-community fire management committees, which include indigenous and peasant communities, neighboring ranches and Mennonite colonies. Communities are adopting best practices of fire use in their agricultural activities and are actively involved in the planning and implementation of actions to prevent and combat forest fires. Controlled burns are scheduled and conducted in a coordinated way with the community, and fire-fighting brigades have been created to strengthen capacity for quick response of communities to prevent larger fires.

Also, an early warning system of fire risk is being implemented at regional and community level, enabling to conduct agricultural burnings during days with lower risk to reduce probabilities of uncontrolled fires. Also, institutions involved in forest fire management are able to take better informed decisions, as they are provided with near real time information on fire risk, active fires and burned areas, as well as historical information, which is available on a web-based system.

**Keywords:** fire management; communities; forest fires; climate change

**Bio:** Veronica Ibarnegaray is the project manager of two community-based fire management projects at Fundación Amigos de la Naturaleza (FAN). She has seven years of work experience on projects related to climate change research and adaptation strategies for food security and biodiversity conservation in Bolivia.

### 16. Vegetation structure of fuel treatments alters fire severity in the wildland-urban interface

***Presenter:*** *Johnson, Morris, Research Fire Ecologist, Pacific Northwest Research Station*
***Additional Author(s):***
*Johnson, Morris, Research Fire Ecologist, PNW Research Station*
*Kennedy, Maureen, Research Scientist, University of Washington*

The 2011 Wallow Fire, largest wildfire in southwestern USA history, burned through thousands of hectares of fuel treatments adjacent to wildland-urban interface communities in eastern Arizona. We quantified fuel treatment performance in changing fuels, fire behavior and fire effects. Thinning treatments significantly changed fuelbed characteristics that facilitate crown fire initiation and spread, and reduced crown fire hazard and severity. Variability in crown scorch significantly differed between untreated areas and treated areas in all three treatment units ($p<0.001$). The distribution of mean crown scorch in the untreated area clustered tightly around 100% for all three units (mean values AP2: 98%, AP6: 98% and NU: 97%), whereas mean crown scorch was lower in the first three treated plots the mean values dropped (AP2: 78%, AP6: 86%. and NU: 92%). Burn severity indices were higher in untreated units compared to treated units. FFE-FVS predicted active crown fire for most untreated plots (AP2: 78%, AP6: 76%. and NU: 100%). Mean torching and crowning indices were lower in untreated plots. This study provides strong quantitative evidence that thinning treatments reduce fire behavior in dry Western forests, even during a fast moving, high intensity wildfire.

**Keywords:** Fuel treatments, crown scorch, fire hazard, wildfire, urban interface, FFE-FVS

**Bio:** Morris Johnson is a Research Fire Ecologist at the Pacific Northwest Research in Seattle, WA.

**17. Fire behavior in masticated fuels: A review**

***Presenter:*** *Kreye, PhD, Jesse, Postdoctoral Research Associate, Mississippi State University*
***Additional Author(s):***
*Brewer, Nolan, Washington State Dept. of Natural Resources*
*Morgan, Penelope, Professor, University of Idaho*
*Varner, Morgan, Assistant Professor, Mississippi State University*
*Smith, Alistair, Associate Professor, University of Idaho*
*Hoffman, Chad, Assistant Professor, Colorado State University*
*Ottmar, Roger, Research Forester, USDA Forest Service*

Mastication is an increasingly common fuels treatment that redistributes ''ladder'' fuels to the forest floor to reduce vertical fuel continuity, crown fire potential, and fireline intensity, but fuel models do not exist for predicting fire behavior in these fuel types. Recent fires burning in masticated fuels have behaved in unexpected and contradictory ways, likely because the shredded, compact fuel created when trees and shrubs are masticated contains irregularly shaped pieces in mixtures quite different from other woody fuels. We review fuels characteristics and fire behavior in masticated fuels across the United States. With insights from the few laboratory and field burning experiments conducted, we highlight the variation likely to occur across different ecosystems in which these treatments are being widely implemented. Masticated debris has a propensity to flame and smolder for long durations. Fuel variability and vegetation response will likely influence whether or not treatments reduce long-term fire hazard. We identify key science needs that will better elucidate fire behavior and effects in these treatments. With mastication widely applied in an expanding wildland–urban interface it is crucial to understand how such fuels burn. What we learn about combustion in these fuels will inform effective fuels management in these and other mixed fuels.

**Keywords:** fuels management, mastication

**Bio:** Jesse Kreye is a postdoctoral research associate in the Forest and Wildlife Research Center at Mississippi State University.

**18. How Fuel Treatment Types, Locations, and Amounts Impact Landscape-Scale Fire Behavior and Carbon Dynamics**

***Presenter:*** *Dicus, PhD, Christopher, Faculty Fellow to the Provost, California Polytechnic State University*
***Additional Author(s):***
*Osborne, Kevin, Fuels Technician, Klamath National Forest*
*Isbell, Clint, Fire Ecologist, Klamath National Forest*
*Weise, David, Supervisory Research Forester, Pacific Southwest Research Station*
*Ager, Alan, Operations Research Analyst, Pacific Northwest Research Station*

When managing for fire across a large landscape, the types of fuel treatments, the locations of treatments, and the percentage of the landscape being treated should all interact to impact potential fire size, intensity, and severity. To investigate these interactions, we utilized forest growth model (FVS-FFE) and fire simulation software (FlamMap, Randig), integrated through GIS software (ArcMap9.3), to quantify the impacts that varied landscape-scale fuel treatments have on burn probability, conditional flame length, mean fire size, short-term carbon loss, and long-term carbon storage. Thirteen fuel treatment scenarios were simulated on a 42,000 hectare landscape in the Klamath Mountains of northern California: one untreated, three proposed by the US Forest Service, and nine that were spatially-optimized and developed with the Treatment Optimization Model in FlamMap. The nine scenarios developed in FlamMap varied by treatment intensity (10%, 20%, and 30% of the landscape treated) and treatment type (prescribed fire, mastication and thin + burn). Each scenario was subjected to 10,000 simulated wildfires with random ignition locations in order to develop burn probability and average flame length values for each scenario. We also recorded mean fire size for each scenario. We used the burn probability values to represent the likelihood of future wildfire occurrence, which we incorporated into our long-term carbon storage projections.

Our results suggest that the influence landscape-scale fuel treatments have on fire behavior metrics (mean burn probability, flame length and mean fire size) and carbon dynamics are indeed highly dependent upon the treatment arrangement, type, and intensity. The results suggest that treating 20% of the landscape appears to be the optimal treatment intensity for reducing fire behavior metrics, and treating beyond this level produces diminishing returns in modification of fire size and behavior. Further, treating 20% of the landscape also most maximizes long-term carbon storage. Of note, we found that prescribed fire treatments resulted in the greatest long-term carbon storage compared to the mastication and thin+fire treatments.

**Keywords:** Wildland fire, WUI, carbon storage, carbon sequestration, simulation, modeling, FVS, FlamMap, treatment optimization, ArcFuels

**Bio:** Christopher A. Dicus is the Faculty Fellow to the Provost at California Polytechnic State University, San Luis Obispo. There, he also coordinates the Wildland Fire & Fuels Program in the Natural Resources

Management & Environmental Sciences Department. He is the Coordinator of the WUI Module of the California Fire Science Consortium and sits on the Board of Directors for the Association for Fire Ecology.

**19. Optimizing the containment of large wildfires**

***Presenter:*** *Martell, PhD, David, Professor, Faculty of Forestry, University of Toronto*
***Additional Author(s):***
*Constantino, Miguel Fragoso PhD, Professor, Department of Statistics and Operations Research Faculty of Science University of Lisbon*
*Fonseca, Maria da Conceição, Professor, Department of Statistics and Operational Research Faculty of Science University of Lisbon*

We describe the development of a decision support system that fire managers can use to help evaluate alternative strategies for containing large wildfires. The problem of determining how best to contain a large wildfire can be viewed as a problem of deciding when and where to establish control lines and what resources will be used to construct and maintain those control lines. We decompose this problem into a two stage iterative process which is initiated by having the operations chief specify a containment strategy that entails determining where a set of control lines are to be located and the times by which the construction of each of those control lines are to be completed.

Once those control line objectives have been established the operations chief's next task is to determine which of the available resources will be allocated to each fireline segment and when they will be scheduled to begin construction of the line segment to which they have been assigned. The fireline construction resources that are available vary with respect to the timing of their availability and their costs and their rates of line construction will vary by the type of terrain in which they are working and the intensity of the fire which will in turn determined by fuel type and fire weather.
We formulate the large fire suppression allocation decision-making problem as an integer linear programming problem and illustrate how it can be used to minimize the cost of achieving the operations chief's control line objectives with the available resources. The operations chief can then combine the cost of line construction and maintenance and the losses associated with the specified fire perimeter to determine the cost plus loss for that particular containment strategy.

The operations chief can then continue with an iterative process by which alternative containment strategies are specified and the cost plus loss of each of them is determined. The iterative process will end when the operations chief is satisfied that he or she has identified a good strategy or has no more time to continue specifying and evaluating containment strategies. We illustrate how our methodology can be used by applying it to a hypothetical fire containment problem and how it can be extended to account for uncertainty concerning rainfall which will impact on fire intensity, fire spread and fireline construction rates.

**Keywords:** large fire management, containment, optimization, integer programming, operations

**Bio:** David Martell is a Professor in the Faculty of Forestry at the University of Toronto. He completed his B.A.Sc., M.A.Sc. and Ph.D. in the Department of Industrial Engineering at the University of Toronto where he studied Management Science and Operational Research and their application to forest fire management. After he completed his Ph.D. he spent part of the 1975 fire season as a member of a fire crew stationed at Shebandowan in Thunder Bay district in Ontario. He was assigned as a researcher to one of Ontario's Incident Management Teams for the 2010 - 2013 fire seasons.

**20. Large wildfire trends in the Western United States from MTBS data, 1984-2011**

***Presenter:*** *Dennison, Phili, University of Utah*

We used burned area boundaries for the Western US from the Monitoring Trends in Burn Severity (MTBS) project to document regional trends in fire occurrence, total area burned, fire size, and day of year of ignition (DOY) for 1984-2011. Over the Western US and in a majority of the nine ecoregions examined, we found significant, increasing trends in the number of large fires and/or total area burned per year. Trends were most significant for southern and mountain ecoregions, coinciding with trends towards increased drought severity. For all ecoregions combined, number of large fires increased at a rate of seven fires per year while total area burned by large fires increased at a rate of 355 km2 per year. Continuing changes in climate, invasive species, and consequences of past fire suppression, added to the impacts of larger, more frequent fires, are likely to result in further disruptions to the fire regimes of the Western US.

**Bio:** Dr. Philip Dennison is an Associate Professor of Geography at the University of Utah and Director of the Utah Remote Sensing Applications (URSA) Lab. Dr. Dennison and his students use remote sensing to map vegetation species and functional types, measure vegetation characteristics related to fire danger, insect damage, seasonal cycles, and invasive species, and to directly measure fire or atmospheric properties.

**21. Catastrophic Fires Down Under Down Under - A Case Study**

***Presenter:*** *Brown, AFSM, BSocSc, MIFireE, EFO, Mike, Chief Officer, Tasmania Fire Service*

On Thursday 3 January 2013 the Australian island state of Tasmania experienced Severe to locally Extreme fire weather conditions. More than fifty fires were reported and several developed into major incidents. But thing wer to get much worse. On that evening the State's capital Hobart recorded its hottest night on record; winds gusted to 100 kph and a band of dry lightning impacted on much of the island State's coastline.
Friday 4 January saw the State experience Catastrophic conditions in several locations.
200 dwellings plus numerous outbuildings, caravans, boats and vehicles were destroyed as the fires burnt across 300,000 acres.
The season lead up and the weather conditions experienced were very similar to Tasmania's 1967 Black Tuesday when more than 2,000 homes were destroyed and 62 people killed.
There were no lives were lost or serious injuries due to the Tasmanian fires in January.
Why, what happened, what was done differently, and what more can be learn?

**Keywords:** Lesson Learnt, Warnings and community behaviour, Operational priorities

**Bio:** Mike is currently Chief Officer of the Tasmania Fire Service (TFS).
Mike's fire service career began in 1977. Since 2009 he has been Chief Officer incorporating the role of CEO and Chairman of the State Fire Commission. He oversees the command and development of TFS's

450 career and support staff plus 5,000 plus volunteer members. Mike is also a board member of the Australasian Fire and Emergency Services Council and Chairs the National Aerial Firefighting Centre Board.
Mike has qualifications in Social Science, and EFO and the IFE.

### 22. Transitioning From A Small Fire: factors Driving Episodic Fire Growth Post-1988 in Yellowstone National Park

***Presenter:*** *Renkin, Roy, Supervisory Vegetation Specialist, National Park Service, Yellowstone National Park*
***Additional Author(s):***
*Smith, Rebecca, Fire Ecologist, Division of Visitor and Resource Protection, Office of Wildland Fire and Aviation, P.O. Box 168, Yellowstone National Park, WY 82190*
*Cataldo, John, Fire Management Officer, Division of Visitor and Resource Protection, Office of Wildland Fire and Aviation, P.O. Box 168, Yellowstone National Park, WY 82190*

A negative exponential decay curve accurately describes the frequency versus size class distribution of lightning-caused fires, regardless of management strategy, in the subalpine forests of Yellowstone National Park. Most fires remain small because fuel, weather, and/or topography are seldom favorable for fire growth. Transitioning from a small to large fire, however, can occur abruptly, especially when a change in weather parameters overcomes fire behavior constraints imposed by fuel, previous weather conditions, or topography. This presentation will examine episodic fire growth on 14 fires (both lightning- and human-caused), greater than 2,500 acres across 11 different fire seasons since 1988 in Yellowstone National Park. Both quantitative and qualitative data will be used to identify conditions supporting large-fire growth with an emphasis on anomalous weather and fire behavior observed during short-duration episodic fire growth. Analysis here identifies four different categories of episodic fire growth driven by different weather variables and their resultant fire behavior.

**Keywords:** episodic fire growth; large fires; fire behavior, Yellowstone National Park

**Bio:** Roy has held a variety of positions in the Resource Management and Research Divisions in Yellowstone throughout his NPS career, now approaching 36 fire seasons in the park. Roy is currently red-carded as an LTAN. His published research interests are with interacting forest disturbances and succession, and their expression on lightning-caused fire occurrence and behavior in the subalpine forests of the park

### 23. Large Post-fire Emergency Stabilization Response Is Not Always Related to Large Fires

***Presenter:*** *Robichaud, PhD, Peter, Research Engineer, USDA Forest Service, Rocky Mountain Research Station*
***Additional Author(s):***
*Rhee, Hakjun, Post Doctorate, University of Montana*
*Lewis, Sarah, Civil Engineer, Rocky Mountain Research Station*
*Ashmun, Louise, Civil Engineer, Rocky Mountain Research Station*
*Albrecht, Conrad, Technician, Rocky Mountain Research Station*

After every major wildfire in the US, a Burned Area Emergency Response (BAER) team assesses post-fire conditions and recommend treatments, if necessary, to reduce potential damage to values-at-risk from flooding and erosion. BAER teams assessing post-wildfire conditions follow a defined protocol and file Burned Area Reports. We have developed an online database BAER DB with over 1500 Burned Area Reports over the last four decades from the Western US Forest Service lands and used this data to examine the reported rational for treatment implementation, treatments used, and relationships among fire size and BAER costs. Treatment justifications generally reflected regional concerns, such as protection of aquatic habitat for threatened and endangered species in the Pacific Northwest and protection of soil productivity in areas that supported a robust timber industry. In the 2000s, BAER treatments were more often justified as protection of life and property than in the 1970s through 1990s, which reflected the increase in the number and size of wildfires and the continued development of the wildland-urban interface (WUI).The greatest BAER costs are generally incurred on fires that have high-cost land treatments, such as aerial agricultural straw mulching, applied over large areas to protect municipal water sources or other valuable resources. Although a small number of large fires generally accounted for most of the area burned in any given year, the largest fires did not result in the greatest BAER expenses; in fact the relationship between fire size and BAER expenditure was weak (R2=0.06) for the 20 fires with the highest BAER expenses. BAER expenditures were driven, not by amount of area burned, but rather by the values-at-risk for damage or loss. Of the three post-fire treatment types: land, road, and channel; road treatments were the most frequently used category of treatments. Low-cost seeding was the most frequently used land treatment; however, the frequency of post-fire seeding decreased from 96% of the fires in the 1970s to 30% in the 2000s. Despite being more expensive than seeding, the use of agricultural straw mulching continuously increased from 1970s to 2000s (2% to 18%) as it was shown to be effective in reducing post-fire erosion. BAER expenses were driven by values-at-risk which suggest proper use of the post-fire assessment process.

**Keywords:** erosion, floods, values at risk, mitigation, assessment, treatments

**Bio:** Pete is a Research Engineer for the USDA-Forest Service, Rocky Mountain Research Station Air, Water and Aquatic Environment Science Program located in Moscow, Idaho. He has a B.S. in Civil Engineering, M.S. and Ph.D. in Agricultural Engineering. He has been studying and modeling soil erosion process, mitigation effectiveness as affected by wildfires in the past 25 years, published over 120 articles and spends his summers chasing wildfires and playing in the dirt!

## 24. Effects of Large Wildfires on Stand Structure and Landscape Diversity in the Pacific Northwest

***Presenter:*** *Reilly, Matthew, Graduate Research Assistant, Oregon State University College of Forestry Dept of Forest Ecosystems and Society*
***Additional Author(s):***
*Spies, Thomas, Research Forester, USDA Forest Service Pacfic Northwest Research Station*

A combination of 20th century fire exclusion and intensive forest harvesting are hypothesized to have reduced structural variation and decreased landscape diversity across the Pacific Northwest. Although few studies if any studies have actually documented the magnitude and extent of effects associated with altered disturbance regimes, there is great concern regarding the return of wildfire to these forests in their current state. In some cases the return of wildfire since the 1980's has resulted in uncharacteristically severe wildfire, while in others there is evidence of resilience and there may be reason to suspect that recent wildfires may actually be restoring forest structure and landscape diversity in some forests. We use data from over 11,000 forest inventory plots sampled between 2001 and 2010 from Oregon, Washington, and northern California to develop a structural classification of forest vegetation based on stand level attributes describing live trees, snags, dead and downed wood, and understory vegetation. We compare the range of structural variation and abundance of classified structural types among the major potential vegetation zones in the Pacific Northwest and then focus specifically on the effects of recent large wildfires. Major differences in structure among vegetation zones are related to dominant climatic gradients, but there is a high degree of similarity among vegetation zones due to shared abundances of moderate and high biomass structural classes with high density, especially in the grand/white fir and Douglas-fir vegetation zones. The effect of several large wildfires on structural variation is evident in dry forests where they have primarily decreased live tree density and increased mean tree size in forests burned at low and moderate severity. Diverse early successional structural types with dead biological legacies are also associated with several large wildfires, but are generally very rare across the region. Although shifts away from historical disturbance regimes during the 20th century have reduced structural diversity in some vegetation zones, recent large wildfires appear to be increasing biodiversity and restoring structural variation across dry forests of the region.

**Keywords:** forest structure, early succesional habitat, Pacific Northwest

**Bio:** Matt Reilly is a PhD candidate at Oregon State University currently studying the effects of contemporary wildfires on regional forest dynamics on the Pacific Northwest. He spent several years researching prescribed fire and wildfire in the southeastern United States and is interested in integrating knowledge on the positive ecological effects of fire in forests of both eastern and western North America.

**25. Effects of Prescribed Burn Regime on Understory Vegetation: A Fifteen Year Response**

***Presenter:*** *Kerns, PhD, Becky, Research Ecologist, USDA FS Pacific Northwest Research Station*
***Additional Author(s):***
*Day, Michelle, Faculty Research Assistant, Oregon State Univeristy*

In the western United States, the Season and Interval of Burn study represents a unique long-term permanent plot study platform that was developed on the Malheur National Forest in 1997 using six upland ponderosa pine forested stands. Established at the request of local land managers to investigate the influence of spring and fall prescribed fire treatments on black stain root disease and its potential insect vectors, the original study was expanded in 2002 to include five and fifteen year burn intervals, and the addition of an array of ecosystem response variables—all largely funded by JFSP and the National Fire Plan over the following decade. We now report on preliminary results regarding the understory vegetation response fifteen years after study implementation, where tree five-year interval burns (1997/1998; 2002/2003; 2007/2008) and one fifteen -year burn (1997) have occurred.
The study is a split-plot randomized complete block design with two factors (season and interval of burn, n = 5) and an unsplit whole plot control. Burn season is a whole plot treatment (control , spring, fall) and the split-plot treatment is burn interval (five-year, fifteen-year). Current years understory plant canopy cover was visually estimated in 2012 and recorded by species to the nearest percentage point on eight

one-m square quadrats within each plot. Data were analyzed as a randomized block, split-plot ANOVA design with an unsplit control in Proc Mixed SAS 9.1 (block was random). Response variables included species functional groups based on morphological, physiological, and phenological traits. The fifteen-year fall burn treatment had higher total vegetative cover than the five-year fall burn treatment ($p = 0.04$). A significant interaction between burn interval and season is noted. Cover of rhizamatous grasses was marginally greater in the fifteen-year spring treatment as compared to the control ($p = 0.08$). Densely tufted bunchgrass cover was marginally lower in the five-year fall burn treatment as compared to the control ($p = 0.08$). No differences were found for cover of open tufted bunchgrasses. Sedge cover was higher in the fifteen-year fall burn treatment as compared to the five-fall year burn treatment ($p < 0.01$). Both burning in the fall (five and fifteen year) and frequent burning in the spring increased the cover of Bromus tectorum, although differences were small. No differences were found for cover of annual forbs. Results suggest important differences due prescribed fire regime that vary based on species functional group.

**Keywords:** prescribed fire, season of burn, interval of burn, ponderosa pine

**Bio:** Becky K. Kerns is a research ecologist with the USDA Forest Service, Pacific Northwest Research Station in Corvallis, OR. She holds a Ph.D. in Forest Science from Northern Arizona University, where she first started working in southwestern ponderosa pine forests. Becky has been conducting research for more than 15 years to develop knowledge and understanding about how natural and human-caused disturbances and their interactions affect the structure and function of plant communities, and how this information can be used to develop management and adaptation practices to achieve land management goals and promote ecological resilience to disturbances. She is currently the PI for the Season and Interval of Burn Study.

### 26. Scale Dependent Vegetation Response to Mixed-Severity Fire and Salvage Logging in Douglas fir/Western Hemlock Forests of Oregon's Western Cascade Mountains

***Presenter:*** *Dunn, Christopher, Ph.D. Candidate, College of Forestry, Oregon State Unviersity*
***Additional Author(s):***
*Bailey, John D., Associate Professor, Oregon State University*

Douglas-fir/western hemlock forests of the western Cascade Mountains are often considered to have a low-frequency, high-severity fire regime, but as one approaches the southern extent of this forest type the fire regime transitions to mixed-severity. These mixed-severity fires create complex patch dynamics that affect woody vegetation recovery at multiple scales. Since 1988, approximately 75,000 hectares have burned in several large fires in this region, providing an opportunity to investigate woody vegetation response to a fire severity gradient at multiple scales. We focused our sampling to fires that occurred >10 years prior to sampling and included salvage logged sites. Sampling was constrained to stands with mature or old-growth Douglas-fir/western hemlock forests prior to the disturbances. A nested, variable radius plot design was used to sample forest structure across the burn severity gradient. A total of 36-1 hectare circular plots were stratified across low, moderate and high-severity fire conditions. We also sampled an additional 12 salvage logged and 6 unburned reference sites. At each plot, 4-nested 0.1 ha forest structure subplots were sampled to capture within plot variability. Shrub cover by species was estimated in 10m x 10m square plots, centered on the 0.1 ha forest structure plots, to investigate local scale variation in overstory conditions on vegetation communities. Regenerating

trees (<2.54cm DBH) were tallied by species in 0.5m height classes within the 10m x 10m understory vegetation plots. All plots were randomly located using classified fire severity maps developed from the relativized difference in the normalized burn ratio (RdNBR). Scale dependent vegetation response to subplot and plot level variables was evaluated using Non-metric multidimensional scaling at the subplot and plot level. Landscape spatial analysis included burned area by severity class, mean patch size, patch density and topographic controls on burn severity. Vegetation communities responded to local variation in overstory abundance at the 0.1 ha subplot scale, especially within moderate severity conditions. Within these moderate-severity conditions, community response tended to be similar to either low or high-severity fire communities, but differentiated from these conditions at the 1-ha scale. Vegetation communities in salvage logged sites were similar to those following high-severity fires, but structure deviated significantly. Our results suggest mixed-severity fire creates highly variable forest structure and that understory vegetation responds significantly to local conditions. Fires burning with mixed-severity are important disturbance events for promoting and maintaining complex forest structure at local and landscape scales, including early seral and late seral forest conditions.

**Keywords:** mixed-severity fire, forest structure and vegetation community response to fire

**Bio:** Chris Dunn is a Ph.D. Candidate and Graduate Fellow at Oregon State University and currently teaches forest ecology and wildland fire sciences for the College of Forestry. His research focuses on vegetation community and carbon dynamics in forest systems following mixed-severity fire and salvage logging. He also remains active as the founder and host of the “Traditional Ecological Knowledge in Ecosystem Sustainability” Conference held at Oregon State University. Before returning to academia he enjoyed a career in fire suppression and fuels management.

### 27. The Combustion of Large Downed Wood: Initial Impacts of Burn Intensity on Soil Nutrients and Ectomycorrhizal Communities of Ponderosa Pine Seedlings

***Presenter:*** *Cowan, Ariel D., Oregon State University*
***Additional Author(s):***
*Smith, Jane E., Research Botanist, USDA Pacific Northwest Research Station*

Exposure of soils to intense heating from high severity fire reduces soil nutrients, water availability, and causes mortality of soil microbes. Climate shifts and fire suppression are predicted to increase the frequency of high severity fires in the ponderosa pine forests of central Oregon. This outlook has created a need to comprehend the potential ecological and timber resource impacts. Ectomycorrhizal fungi (EMF) are soil organisms affected by fire. EMF are considered essential for conifer seedling growth and establishment by aiding seedlings in water and nutrient capture. Previous studies, showing EMF improve ponderosa seedling growth and survival after fire did not compare community composition between low and high intensity burned soils in a field setting. Do soil nutrients and EMF community composition differ between high and low intensity burned soils? If so, how might these differences impact ponderosa pine regeneration? Burn intensity impacts were compared in a thinned ponderosa stand on Lookout Mountain, Pringle Falls Experimental Forest, La Pine, OR. Three treatments were applied using prescribed burn: high intensity burn (HB), low intensity burn (LB), and unburned control (UB). All three treatments were replicated in twelve different sites. HB treatment was created by the combustion of downed logs stacked together. Thermocouple probes were used to record burn temperatures at multiple depths within the soil. Findings will be presented on whether or not a) lower soil nutrient

concentrations were present in HB soils compared to LB soils, b) ponderosa pine seedlings grown in HB soils had lower EMF species richness and relative abundance than those grown in LB soils, and c) correlations exist among treatments, soil nutrient concentrations, and EMF community composition. The goal of this study is to elucidate the initial impacts of high intensity fire on the belowground ecosystem supporting ponderosa pine growth and survival. The results will contribute to the scientific knowledge of severe fire impacts and could influence fuel reduction practices in forest management. Primary succession of EMF after fire is not well understood and this research aims to advance our understanding of EMF community assembly and its role in fire ecology.

**Keywords:** Ponderosa pine, prescribed burning, Oregon, ectomycorrhizal fungi, soil nutrients, fire intensity

**Bio:** Ariel Cowan is a second year master's student at Oregon State University's College of Forestry. She is originally from Brooklyn, NY and has a degree in Environmental and Forest Biology from the State University of New York College of Environmental Science & Forestry. Besides studying ectomycorrhizal fungi, she is interested in disturbance ecology, dendrology, biological soil crusts, and the impact of invasive plants. She has enjoyed working in a wide variety of landscapes such as northern hardwood forests, California oak woodlands, coastal scrub, redwoods, Russian taiga, sagebrush steppe, juniper woodlands, and the dry ponderosa forests of Central Oregon.

**28. Once Burned Twice Shy: How Multiple Fires and Wind+Fire Combinations Alter Successional Patterns in the Boreal Forest**

***Presenter:*** *Anoszko, Elias, PhD candidate, University of Minnesota*
***Additional Author(s):***
*Frelich, Lee, Research Associate, University of Minnesota*
*Reich, Peter, Professor, University of Minnesota*

Current climate change research projects a doubling in fire frequency throughout most of the North American boreal forest by the year 2100. At the same time, severe windstorms are likely to become more frequent as warm, humid air masses are able to push further north under a warming climate. These changes in boreal disturbance regimes are likely to result in increased incidence of multiple compounding perturbations, or multiple disturbances, within a short period of time, with uncertain impacts on succession and biodiversity. A series of recent disturbance events in the southern boreal forest of the Boundary Waters Canoe Area Wilderness of Northern Minnesota including a severe windstorm in 1999 (193,000 ha) and two large wildfires in 2006 and 2007 (40,000ha), along with several smaller fires between 1974 and 2006, have created a unique matrix of fire and wind disturbance combinations that serve as a case study for examining how boreal forest systems will respond to changing disturbance regimes. Using a network of permanent monitoring plots we followed changes in forest succession and tree diversity in forest stands that were variously subjected to fire alone, wind alone, wind + prescribed fire, wind + prescribed fire + wildfire, wind + wildfire, and 2 or 3 fires within a 35 year period. In cases of multiple disturbances we found strong successional convergence towards forests dominated by aspen and birch while stands subjected to single disturbance exhibited multiple successional pathways and mix of both late successional and early successional regeneration. Disturbance combinations also showed reduced beta diversity when compared to stands affected by single disturbance events. Our results suggest that predicted changes in boreal disturbance regimes

could adversely affect sensitive species and result in reduced biodiversity and possibly impaired ecosystem functioning.

**Keywords:** Multiple Disturbances, Blowdown, Fire Ecology, Succession, Biodiversity

**Bio:** Elias Anoszko, a Wisconsin native, is a PhD candidate at the University of Minnesota studying the effects of multiple disturbances on forest succession in the boreal forest. Prior to starting his Phd studies he worked for three seasons as crew leader and botanist for the USFS Pacific Southwest Research Station on projects related to fire ecology in the Sierra Nevada Mountains. Most recently he spent four months in Estonia and other Baltic States studying the affects of wind disturbance on hemi-boreal forests.

**29. Multi-Severity Fire Effects in Xeric Oak-Pine Communities Following Small Fires in the Great Smoky Mountains National Park**

***Presenter:*** *Abla, Scott, Western Carolina University*
***Additional Author(s):***
*DeWald, Laura E. , Western Carolina University*

Fire suppression has changed species composition in xeric oak-pine forests across the southern Appalachians. Improved understanding of fire-related ecological mechanisms will improve effectiveness of fire management decisions. Although occurrence of fire is known to be related to ecosystem functioning, specific effects of multi-severity fires are not as well understood. Reflectance-based satellite image maps have effectively been used to predict on-the-ground burn severity and changes in vegetative patterns following large fires of different severity across the US. It is less understood how effective burn severity maps are at quantifying multi-severity fire effects on vegetation following smaller sized fires typical in southern Appalachian forests. The purpose of this study was to determine if fire severity designations were consistent between satellite imagery and ground-based methods and to evaluate ecosystem effects of different fire severities in xeric oak-pine ecosystems in the Great Smoky Mountains National Park (GSMNP). Plots were randomly located using satellite-based burn severity maps, and ground-truthed using the FIREMON Composite Burn Index. Fire severity ratings based on satellite imagery were strong correlated to ground-based ratings for 169 total plots ($p<0.01$, R2=0.78). This relationship was strongly correlated among different xeric forest types, fires occurring at different times, and among different burn severities. Variables related to stand regeneration were measured at the ground, mid-story, and over-story layers among different burn severities including no-burn sites. Results showed over-story mortality increased with higher burn severity and fire at all severities reduced litter layer and shrub cover by over 50% while grass cover and coarse woody debris increased. Species richness did not differ among severities in ground and mid-story layers. However, desired xeric pine and oak regeneration was greater at higher fire severity. Maple was the dominant species in the ground and mid-story layers (seedlings in unburned sites, sprouts in burned sites), but mid- and over-story basal area decreased significantly with fire severity. Changes in species composition following fire were caused by greater amount of exposed mineral soil, increased light penetration to forest floor, and reduced mid-story stem densities. Results show that satellite imagery can be used to predict on-the-ground severity and that different fire severities are related to specific changes in forest structure and species composition. These results will help fire managers predict successional changes following multi-

severity fires and design fire-management applications to create conditions that promote xeric oak-pine regeneration and thus help protect this ecosystem in the Southern Appalachians.

**Keywords:** fire ecology, remote sensing, CBI, multi-severity, southern Appalachians

**Bio:** Scott Abla is a 2nd year graduate student at Western Carolina University. He is studying fire effects in the Great Smoky Mountains National Park. Scott is a certified arborist and enjoys kayaking and rock climbing. He has a dog and lives with his girlfriend in Maggie Valley, NC.

### 30. Experimental Evidence That Surface Mulch Applications Alter Soil Nitrogen Cycling Following High-Severity Wildfire

***Presenter:*** *Penelope Morgan, Professor, University of Idaho, Department of Forest, Range and Fire Sciences, Moscow, Idaho*
***Additional Author(s):***
*Berryman, Erin, Assistant Professor, Colorado State University*
*Peter Robichaud, Research Engineer, USFS-Rocky Mountain Research Station, Moscow, Idaho*
*Deborah Page-Dumroese, Research Soil Scientist, USFS-Rocky Mountain Research Station, Moscow, Idaho*

Mulch is commonly applied following large wildfires that put ecosystem values, such as water quality, at risk. Mulch has the potential to alter nutrient cycling compared to areas that are allowed to naturally recover following high-severity wildfire. On the 2012 High Park Fire, a wildfire that burned in the Front Range near Fort Collins, Colorado, we used a randomized block design to monitor surface mulch impacts on soil carbon, soil nitrogen and plant responses in a lodgepole pine-spruce-fir forest. We compared three common post fire mulches: wood strands, wood shreds, and agricultural wheat straw, each applied at two different levels of surface coverage. In addition, we included a non-decomposing mulch to separate effects of mulch decomposition from changes in soil environment. The fire burned through the end of June 2012, and mulch treatments were applied in mid-July 2012.
By October 2012, areas mulched with wheat straw showed higher plant cover than the other mulches; this was mostly wheat grass. Grass cover in the wheat straw plots was lower the following year but also high compared to the other mulches. The year following the mulch applications, tree seedling counts were higher in all mulched plots compared to the unmulched plots. Increased plant cover was not related to soil nitrate availability as measured by buried anion exchange probes. Increased carbon mineralization was correlated with reduced nitrate availability in all mulched plots, suggesting that the mulch altered nitrate transformation rates. This was most dramatic in the wood mulched (strands and shreds) plots, supporting the idea that soil amendments with high C:N (like wood) promote nitrate immobilization as the C in the mulch is metabolized by microbes. During the summer months, soil moisture was about twice as high underneath mulched plots compared to unmulched plots, an environmental alteration that can also affect microbial C and N transformations. Because nitrate levels were overall higher in mulched plots, we suspect that any N immobilization effects of the mulch are more than compensated for by the acceleration in N mineralization resulting from the more favorable soil moisture levels promoted by the mulch cover. Such an increase in N availability has ramifications for post fire ecosystem recovery, e.g., invasion of exotic annuals. Future monitoring work over the next several years is necessary to determine the persistence of these mulch effects in this critical phase of post-burn ecological recovery.

**Keywords:** post fire rehabilitation, forest recovery, erosion mitigation, aerial mulching, nitrate, carbon, decomposition

**Bio:** Penny Morgan is a professor in the College of Natural Resources at the University of Idaho. She directs the University's Wildland Fire Program. The fire program has been educating and working with leaders in fire education, research and outreach for more than 30 years. Penny was born, raised and educated in the West. She earned her bachelor of science and master of science degrees from Utah State University and holds a doctorate from the University of Idaho. Her current research focuses on some of the broad challenges facing people in the West: How will the changing climate influence fire occurrence and severity? Where, when and why do fires burn severely? How do bark beetles affect crown fire hazard in forests and burn severity? What drives landscape dynamics, and how can we best manage landscape change? How does vegetation recover following large fires, and how does post-fire management affect weeds and other vegetation regrowth? Penny is committed to helping people understand and use science in natural resources management in Idaho, the western U.S., and beyond.

**31. Society, Politics, and Large Wildland Fires: Examining the Political and Social Factors Affecting the Diffusion of Wildland Fire Policies and the Cost of Large Fires**

***Presenter:*** *Tripp, PhD, Winston, Assistant Professor, Department of Sociology/ University of West Georgia*

In recent years, scientists who study wildland fires have increasingly identified the need to include social and political factors into their analyses. However, few datasets currently exists combining a broad enough range of these factors for a comprehensive analysis. In this research, we incorporate both political and social factors into our analyses by combining data from the U.S. census, data on the political composition of state governments take from their websites, and data on large fires taken from several national sources including the National Incident Situation Report. First, we look at the political and social factors affecting the diffusion of various wildland fire policies across states, such as regulations, education programs, and community development plans. Second, we examine how these factors affect the cost of large fires, both within as well as across states, accounting for fire characteristics and fire severity conditions. Finally, we analyze how large fires differentially affect communities based on size, population density, and mean income levels.

**Keywords:** Large Wildland Fires, Political Factors, Social Factors, Fire Suppression Costs

**Bio:** Winston Tripp spent ten years as a wildland firefighter for the U.S. Forest Service and Bureau of Land Management. After receiving his B.S in Sociology from the University of Oregon he earned his M.A., and Ph.D. in Sociology from the Pennsylvania State University. He is currently Assistant Professor of Sociology at the University of West Georgia. His research interests include the environmental movement, political change, and the effect of socio-political forces on land management policy.

**32. An Exploration of Warfighting and Firefighting Doctrine**

***Presenter:*** *DeGrosky, PhD, Michael, CEO, Guidance Group, Inc.*
***Additional Author(s):***

*Alen Slijepcevic Deputy Chief Officer Country Fire Authority*

Over the past two decades, wildland fire professionals confronted worsening conditions including the effects of climate change, severe fire behavior, escalating threats to communities, mounting costs, undesired fire effects, unacceptable threats to firefighter safety and survival as well as large amount of indiscriminate public scrutiny through media and post crisis inquiries and litigation. These trends cry out for change and new ways of thinking to better address these rising and complex challenges. Change requires a framework within which people reliably translate policy into timely, effective action. It has been suggested that doctrine represents the framework within which land management agencies and rural fire services can change to confront their challenges. A good doctrine meets three needs; establishing common purpose, creating common language for expressing organizational strategy, and institutionalizing a common structure for action. Some agencies have invested in doctrine, naturally turning to visible experts; the military, for inspiration. Doctrine is fundamental to war. As defined in Warfighting, the United States Marine Corps' handbook on strategy and operations, doctrine is "the fundamental beliefs of the Marine Corps on the subject of war, from its nature and theory to its preparation and conduct. Doctrine establishes a particular way of thinking about war and a way of fighting, a philosophy for leading Marines into combat, a mandate for professionalism, and a common language. In short, it establishes the way we practice our profession." However, while parallels seem obvious, the analogy between warfighting and firefighting breaks down quickly. According to Marine Corps doctrine, “War is a state of hostilities that exists between or among nations, characterized by the use of military force. The essence of war is a violent clash between two hostile, independent, and irreconcilable wills, each trying to impose itself on the other.” Considering this definition of war, no “war on fire” exists. There is no enemy. The human effort is directed at overpowering, not other humans, but a natural force that occurs in places, at times, and with intensities that we, as humans, find unacceptable. Under those circumstances, we actively fight fire. However, only one will exists, that of humans to impose our preference upon the forces of nature. Because firefighting is a civilian undertaking with no moral equivalence to war, the mission is not paramount over the safety of individual firefighters. Firefighting is not warfighting. However, eight concepts embodied in United States Marine Corps doctrine, appear relevant to wildland fire; and the authors explore how those eight concepts might form the core of a fire operations doctrine.

**Keywords:** Doctrine, Human Factors, Operating Environment

**Bio:** Michael DeGrosky is Chief Executive of Guidance Group, Inc. a consulting firm specializing in the human and organizational aspects of the fire and emergency services. He is an experienced wildland and municipal fire professional with an emergency service background spanning 36 years. Mike earned a PhD focused on organizational leadership with Northcentral University. He is also an alumnus of the University of Montana, School of Forestry and Fort Hays State University, College of Business and Leadership, where he earned a master’s degree in organizational leadership.

### 33. The Timeline of Media Manipulation during and after a Large Scale Wildfire

***Presenter:*** *Handy, Ryan Maye, Environment and Public Lands Reporter, The Fort Collins Coloradoan newspaper*

No reporter likes to be manipulated. No evacuated homeowner likes to feel out of the loop during a disaster. But during large scale wildfires, which increasingly attract world-wide media attention, local officials and fire managers must be very careful about the messages they send to their public.
How information is conveyed during a wildfire is crucial the public's perception of how the fire was managed. U.S. Forest Service studies have shown that communities destroyed by large wildfires are more satisfied with fire managers who have been more communicative, and who they trust. As a reporter who covered the Waldo Canyon and Black Forest fires—the two most destructive fires in Colorado history—I have seen two very different reactions to fire management as a result of how incident commanders, sheriffs, and mayors communicated with their communities.

Coverage of a wildfire is inescapable—reporters will always be asking for more access. But coverage also has its own timeline. When a fire first breaks out, everyone is on initial attack—from firefighters to reporters. But as time goes on, I have found that recovery and fire managers forget that reporters still have a job to do, namely, inform the public. All disasters are local. And once the national media outlets are gone, local reporters and community members are in it for the long haul—years of possible recovery.

This talk would focus on how fire managers' and local officials' relationships with reporters evolved during two large wildfires, and what reporters and the public expect to learn from those officials over the long term.

**Keywords:** Media public information wildfire recovery

**Bio:** Ryan Maye Handy is the environment and public lands reporter for The Fort Collins Coloradoan. Previously, she was the wildfire reporter for The Gazette in Colorado Springs, where she covered the Waldo Canyon fire and Black Forest fires, the two most destructive fires in Colorado history. She has written about wildfires, recovery, and disaster management for both papers.

## 34. Housing Development and Rebuilding after Wildfire: Rebuilding and policy responses after fire on the Colorado Front Range, 2010-2012

***Presenter:*** *Hammer, Roger, Professor, Oregon State Univesity*
***Additional Author(s):***
*Stewart, Susan, Researcher, University of Wisconsin*
*Radeloff, Volker, Professor, University of Wisconsin*
*Hammer, Roger, Professor, Oregon State University*
*Mockrin, Miranda, PhD, Research Scientist, USDA Forest Service*

The number of structures destroyed by wildfire is rising, highlighting the costs of fire management in the wildland urban interface. Since 2000, approximately 1,300 residences have been lost annually to wildfire. In response, fire policy now emphasizes the need to create fire-adapted communities, where the community takes responsibility for its wildfire risk by protecting residents and homes through preparedness and risk mitigation. Yet we know little about how wildfire occurrence and structure loss affects a community's development patterns, and how individuals and institutions shape these patterns. We propose that studying individual and community response after wildfire will provide valuable insight into the process of fire-adaptation. Therefore, we documented housing loss, recovery, and new policy

initiatives after three destructive fires along Colorado's Front Range from 2010-2012: the 2010 Fourmile Canyon Fire outside Boulder (homes lost = 169), the 2012 High Park Fire outside Fort Collins (n=259), and the 2012 Waldo Canyon Fire outside Colorado Springs (n=346). Rates of rebuilding varied across fire incidents: a year after the fire approximately 20% of those who lost homes in the High Park fire had rebuilding permits vs. 50% for the Waldo Canyon fire (Fourmile Canyon had intermediate rates). Each community had varying approaches to facilitating and guiding rebuilding in an adaptive manner. For the Fourmile Canyon fire existing code meant that all new homes are built with fire-resistant materials and have vegetation mitigation, for the High Park fire there were no additional requirements for fire-resistant materials, but a non-profit organization encouraged their use, while after Waldo Canyon fire building codes were strengthened. For all locations it is unclear if mitigation will be maintained over time, and there are no requirements that older homes be retrofitted and/or mitigated. In all three locations, homeowners experienced emotional, financial, and logistical challenges to rebuilding, but those who rebuilt felt strong attachments to the area, and were determined to rebuild, indicating that government regulations and response will play an important role in guiding rebuilding and fire-adaptation.

**Keywords:** WUI, structure loss, rebuilding, fire-adapted communities, governance

**Bio:** Roger Hammer is associate professor of Public Policy at Oregon State University. Roger's research efforts focus on the social, economic, and environmental determinants and consequences of population growth and redistribution, with an emphasis on improving understanding of the spatial dynamics of these processes. With colleagues at the University of Wisconsin and the USDA Forest Service he has developed and refined maps of the Wildland Urban Interface and conducted a number of studies related to wildland fire and the WUI. Roger received a MS and Ph.D. in Sociology from the University of Wisconsin – Madison and a Master's of Regional Planning from Cornell University.

**35. Wildfire Loss Prevention - Insurance Resources**

***Presenter:*** *Torgerson, David, PE, Wildfire Defense Systems*

Insurance Companies have a natural interest in the increasing trend of homeowners living in Wildland Urban Interface throughout the West and some insurance companies have re-engaged in Wildfire Loss Prevention through programs including policyholder education, underwriting requirements and engine response operations. Presently over 1.0 million or approximately 10 percent of all homeowner policyholders in the West have wildfire loss prevention services as part of their homeowner's policy. By 2014 that number is expected to increase to 2.0 million policyholders or 20 percent of all homeowners in the West.

Wildfire Defense Systems, Inc. (WDS) has been the largest provider of Insurer Wildfire Loss Prevention Services in the nation with comprehensive Insurer Wildfire Loss Prevention Program services across 14 states since 2008. Currently WDS serves three of the top ten national homeowner policy Insurance Carriers, along with other specialty Insurance Providers as well. WDS has performed 10's of thousands of policyholder education site visits with wildfire property risk assessment report production. WDS has also responded to 150 wildfire incidents across the West and Texas on behalf of Insurance Providers and their policyholders. Using fully qualified and inspected Engines and Crews under NWCG and USFS, these WDS Programs have achieved a 95 percent success rate for ICT authorizations granted to WDS Insurer

Engines, to operate within evacuation zones to perform pre-suppression and suppression operations to increase survivability of insured properties.

Social and Political Implications
In the effort to educate homeowners to the value of a Firewise property or Wildfire Adapted Communities, public agencies have been a constant champion to affect public awareness and change. But unique to the Insurer Wildfire Programs is the opportunity to have the permission for a direct outreach and individual discussion with policyholders regarding their own personal wildfire threat and mitigation measures. These Insurer Wildfire Programs are the next step in affecting public awareness and implementation of more wildfire sustainable properties and safer environments for policyholders and responding firefighters.

While there are little political implications with promoting the principles of Firewise properties, the development of Insurer Wildland Engine response operations has had significant amount of political inquiry. Late in the 19th /early 20th century, Insurer Engines were commonplace. With the re-emergence of Insurer Wildland Engines, old stereotypes are applied, but the modern day Insurer Wildland Engines with qualified and professional Wildland Engine operations which, in the case of WDS operations, are sourced from the same pool of contractor engines dispatched by the USFS.

**Keywords:** Insurance, loss prevention, engine resources

**Bio:** Mr. Torgerson is a licensed, professional civil engineer with 23 years' experience in civil/environmental engineering, Insurer wildfire loss prevention, and hazmat emergency services management. He has been responsible for design and implementation of more Insurer Wildfire Loss Prevention Programs than any other service provider. These wildfire loss prevention programs include elements of underwriting design, inspection, policyholder education, cartography, real-time wildfire exposure reporting and response for structure protection services.

### 36. Do we Learn from Disaster?

***Presenter:*** *Handmer, John, Professor, Centre for Risk and Community Safety, RMIT*
***Additional Author(s):***
*Thornton, Richard, Bushfire and Natural Hazards CRC*

Wildfire disasters provide an opportunity, and highlight the need to learn and improve so as to reduce the risk of similar events in the future. In Australia, public enquiries typically follow major fires and other disasters in Australia, with a mandate to reduce future risk. The enquiry into the February 2009 Victorian fires illustrates the approach. It commissioned over 50 independent pieces of research, solicited expert testimony from across Australia and internationally, received over 1200 written submissions, and interviewed or otherwise heard from many people and organisations. Taken as a whole the enquiries 67 recommendations would likely lead to a transformation in fire risk management. Government accepted all the recommendations, although there was hesitation about those concerning avoidance of "unacceptably high risk" locations, and the allocation of funds for implementation suggested slightly different priorities to those of the enquiry. Separate to the enquiry, the fire itself had impact. Before the enquiry reported, Australian fire related agencies adopted a different fire danger and warning system. Some agencies formally altered their fire-fighting approach to explicitly take account of the different circumstances presented by very high fire danger levels. Fire risk education changed from asking people to decide in advance what they would do, to urging people to leave on "Code Red" days. The 2009 fires were only one of a number of events in Australia leading to major public enquiries and their recommendations over the last five or so years. Some commentators suggest that there is a history of similar recommendations repeated by successive enquiries indicating a failure to learn. This raises a number of issues about learning and improvement which this presentation examines. It looks at the evidence that the 2009 enquiry, government commitments and associated activity reduced the risk; whether fire, land and emergency management agencies find it easy to learn and improve; and to what extent the agencies are centrally relevant to fire risk reduction.

**Keywords:** Fire risk, public enquiries, learning, improvement, Australia

**Bio:** John Handmer is an Innovation Professor at RMIT University, Melbourne. He leads the University's Centre for Risk and Community Safety and its Human Security & Disasters Program. Until 2012 he was Convener of the National Climate Change Adaptation Research Network for Emergency Management, was a Convening Lead Author for the IPCC's Special Report on Extremes, and holds a number of advisory and adjunct positions. He works on the social and economic aspects of emergency management and climate change adaptation in Europe, Australia and the south-west Pacific. His most recent book (2013 with Steve Dovers) is the Handbook of disasters and institutions: improving emergency management and climate change adaptation.

### 37. Operational Test Results and Technical Description of the Xiomas Airborne Wide Area Imager

***Presenter:*** *Green, John, Principle Investigator, Xiomas Technologies, L.L.C.*
***Additional Author(s):***
*Hinkley, Everett A., National Remote Sensing Program Manager, USDA Forest Service*
*Johnson, Jan, Remote Sensing Specialist, RedCastleResources Inc.*
*Quayle, Brad, RS/GIS Specialist, USDA Forest Service*
*Ambrosia, VIncent, Associate Program Manager - Wildfire, NASA Applied Science Program, California State University Monterey Bay*

The Airborne Wide Area Imager for Fire Mapping and Detection (WAI) has been developed by Xiomas Technologies under the NASA Small Business Innovation Research (SBIR) program. Xiomas worked with NASA and U.S. Forest Service personnel during the development process to incorporate both operational requirements and the latest technologies in the innovative design of the WAI.
The overall goal of the WAI SBIR project is the development of an airborne sensor, which could increase the efficiency of the National Infrared Operations (NIROPS) by fielding a sensor that covers more ground in less time and with higher spatial resolution. It has been demonstrated that this technology will reduce the NIROPS flight time significantly (by approximately a factor of 2).
As of this report the WAI has flown about 20 flights, including a number of engineering tests, calibration flights, several flights for a commercial imaging project, and the fire mapping flights detailed here.
A multi-day Test and Evaluation mission was conducted during July 23-26, 2013 to operate the WAI sensor over active fires and measure operational fire parameters. The WAI sensor was evaluated in an operational environment to assess its operational capabilities for active fire and post-fire mapping support. High-resolution two band thermal infrared imagery of active wildfires was collected and

provided to the Forest Service for evaluation to determine their utility in deriving standard tactical fire mapping/geospatial products.

Based on engineering flight test results, we have shown that the WAI is capable of detecting a 6 inch by 6 inch fire from an altitude of 35,000 feet. Acquisition rate will vary based on altitude above ground and speed. As an example, the system can be configured to operate at 17,000 feet above ground and at typical cruise speed of 210 knots the system will map approximately 680,000 acres per hour.
The presentation includes detailed results of the fire mapping flights in addition to an overview of the engineering test flights and commercial imaging project. A technical overview of the sensor is presented as well as a discussion of ongoing activities to further develop the technology for space-based operation, and for persistent/staring operation.

**Keywords:** Thermal Infrared, Wide Area Imaging, Direct GeoCoding, Fire Mapping

**Bio:** John Green is President, System Engineer, and Principle Investigator at Xiomas Technologies in Ypsilanti MI. Mr. Green has been involved in the development and operation numerous imaging systems in use throughout the world including NASA's MODIS Airborne Simulator (MAS) and Airborne Modular Sensor (AMS), and the U.S Forest Service Firefly and Daedalus sensors.
Since starting Xiomas in 2007, Mr. Green has been the Principle Investigator on several Small Business Innovative Research projects including the Airborne Wide Area Imager for Wildfire Mapping and Detection, the Thermal Mapping Airborne Simulator, and the Staring Wide Area Imager.

**38. Emerging Technology in near-time flow for wildfire applications**

***Presenter:*** *Allison, Kristen, Fuels Specialist, BLM*
***Additional Author(s):***
*Ramirez Joaquin, Owner and principal scientist at Technosylva*

Data flow utilizing apps, HUD (ie Google Glass), & emerging technologies (smart watches). The ability to move near time GIS data to create & leverage near-time situational awareness to provide decision support. Using layer files in applications and the ability to share geo-intel on the incident as well as geo-referenced PDF, geo-tagged photos & true near-time video shares. Field personal are constantly at the mercy of information that they can glean, this gives them near-time decision support

**Keywords:** Near-time Data, emerging technology, field

**Bio:** Kristen has been working in wildland fire since 1996. More recently she has been working on merging out-of the box emerging technologies in Geospatial Analyst with Fire Behavior programs.

**39. Improving Usefulness of Information Syntheses for Fire Managers**

***Presenter:*** *Smith, Jane Kapler, Ecologist, Rocky Mountain Research Station, Missoula Fire Lab*

Fire managers often request syntheses of information, and the research community has responded by publishing syntheses at both regional and national scales. Unless these syntheses are designed with a clear vision of the product needed, however, they may not meet their objectives. This project provides recommendations for developing scientifically sound syntheses with maximum usefulness for managers and field practitioners.

The project focuses on improving syntheses for fire management, but findings can also be applied to other natural resource fields. Recommendations are based on experience, literature sources, and interviews with scientists, managers, field practitioners, and science delivery specialists.
Several steps are essential for developing a high-quality synthesis. First, articulate the scope and objectives collaboratively at the outset of the project. Both developers and potential users must be included in this step. The kind of synthesis to be developed depends on its objectives—to describe fundamental concepts regarding a topic, assess the effectiveness of management strategies, provide a comprehensive review of available information, or a mixture of these. Second, determine the best, unbiased methods of searching for information. Third, develop the synthesis following principles for good technical writing, including: organize information according to criteria that readers are likely to use in searching for it; highlight applications wherever possible; write concisely and directly, minimizing jargon and acronyms; and document thoroughly. Fourth, package and publish the synthesis so readers can easily locate the information they need and identify its scientific basis. Finally, distribute it so potential users can find it easily and locate any updates or supplemental materials published after its completion.

Because information on fire management continues to increase, the need for syntheses and the number produced will continue to increase. They must be clear, well documented, well packaged, and effectively distributed so the best available knowledge on fire management will be widely used.

**Keywords:** Synthesis, Fire Management, Information

**Bio:** Jane Kapler Smith is manager of the Fire Effects Information System (FEIS) and a technical editor for three volumes in the “Wildland Fire in Ecosystems” series. She develops communications programs relating to wildland fire, including the FireWorks educational trunk and curriculum. She has studied fire behavior and fire effects in aspen stands of north-central Colorado, taught biology and biostatistics, and conducted research on succession and acid rain in the hardwood forests of western New York. Jane has a B.A. from Alverno College, Milwaukee, Wisconsin and an M.S. in Forest Ecology from Colorado State University.

### 40. Restorationist Fire Use for Ecological Fire Management: Managing Large Wildfires by Design

***Presenter:*** *Ingalsbee, PhD, Timothy, Executive Director, Firefighters United for Safety, Ethics, and Ecology (FUSEE)*

Past fire exclusion policies and fire suppression actions have led to a historic “fire deficit” on public wildlands. However, climate change is creating conditions more conducive to more frequent large-scale wildfires. Politicians, the newsmedia, and agency officials frame large wildland fires as a problem, but they could actually provide fire managers an opportunity to recover fire-dependent species and restore fire-adapted ecosystems that have been adversely affected by the fire deficit.

Despite progressive changes in fire policy over the last 40 years encouraging more fire use in land management, over 98 percent of all wildfires are aggressively suppressed. There is growing evidence that “suppressionist” fire use is being extensively applied on large wildfires. While large-scale burnout and backfire ignitions are intended to limit fire spread, paradoxically, they may account for a significant amount of burned acreage. However, suppressionist fire use does not consider the ecological effects of firing operations, and they may actually magnify or intensify the disturbance effects of wildfire. “Restorationist” fire use is rarely authorized on large wildfires, but even when it is, managers are often hesitant to publicly acknowledge it, preferring to use the euphemism “managing wildfire for multiple objectives.” Part of the reticence of managers comes from assumptions that the public opposes fire use and regards it as a passive “let burn” response. Fear of public opposition to restorationist fire use often propels managers to order aggressive suppression actions even when conditions make them counterproductive or futile.

This presentation will describe a vision of ecological fire management (EFM) that holistically synthesizes the principles and practices of prescribed fire, wildland fire use, and wildfire suppression. With EFM, preplanned restoration goals will guide management actions—including suppression actions--on every large wildfire. However, suppression will be redefined from its current frame of “aggressively fighting” to limit large fire size, to one of actively managing to mitigate uncharacteristically high fire severity. Fire use will be a major tool in EFM, actively applied to steer, slow down, or speed up rather than stop fire spread. With increased restorationist fire use, many wildfires will become large by design.
Progressive managers have been applying aspects of EFM to restore fire processes for several decades, but their accomplishments have gone unheralded. This presentation will advocate for institutionalizing EFM as the guiding philosophy for managing large wildfires, and offer advice on how fire managers can articulate EFM to gain public support for active fire use.

**Keywords:** fire use, ecological fire management, ecological restoration

**Bio:** Timothy Ingalsbee, Ph.D. is the executive director of Firefighters United for Safety, Ethics, and Ecology (FUSEE), co-director of the Association for Fire Ecology, and an adjunct instructor and faculty research associate in Environmental Sociology at the University of Oregon. Timothy served as a wildland firefighter for the U.S. Forest Service and National Park Service. In 1993 Timothy received the Oregon Conservationist of the Year Award. In 2002, he served on the Western Governors' Association's stakeholder group for the Ten-Year Comprehensive Wildfire Strategy and National Fire Plan. Timothy is a senior wildland fire ecologist certified by the Association for Fire Ecology.

### 41. Reconsidering Wildland Fire Use: Perspectives from the Northern Rockies

***Presenter:*** *Seielstad, Carl, Associate Professor, Fire Sciences and Management, The University of Montana*

The idea that more wildfires should be allowed to burn for resource benefit is widespread in federal fire management in the United States and the fire research community is heavily invested in strategies, tools, data, and information to encourage changes in decision-making to support these fires. In the context of the very large wildfires that are now occurring with some frequency around the globe, it is generally believed that the heterogeneity produced by previous fires will confer some benefit when large fires threaten. This paper examines whether federal fire management policies and practices in the United States are evolving to support more widespread use of fire. It argues that new fire policy (2009) which intended to increase decision flexibility by putting all management options on the table for every fire has inadvertently discouraged many managers from preparing adequately for resource benefit fires. The consequence is stagnation in strategic use of wildfire to explicitly improve forest health, treat fuels, and reduce costs, accompanied by deterioration in experience, energy, and enthusiasm for use of fire for resource benefit. Decades of fire use show that without extensive planning, an alternative management option will almost never be selected as the first choice. Even when resource benefit is promoted in Fire Management Plans, it is seldom considered seriously outside of legacy areas. Further, existing decision support systems are not often invoked to support the first and most important decision on new starts. Instead, initial decisions are made quickly, often under duress, by a few individuals present when a fire is detected. In short, DSS's are mostly used to document decisions already made and to help fire managers develop strategies and tactics for escaped fires and fire use in legacy areas. The sense of purpose and energy of the Wildland Fire Use community of a decade ago provided powerful motivation for change as well as vectors for distribution of new ideas and approaches. That community has largely dissolved, the power of the WFIP has been removed, and it is uncertain whether new policies and practices are advancing resource benefit fire as intended. It is worth considering whether fire management removed the distinction between Fire Use and Suppression too soon and made it too easy to select the status quo.

**Keywords:** Fire Use, Resource Benefit, Policy

**Bio:** Dr. Seielstad is an Associate Professor of Fire Sciences and Management in the FireCenter at The University of Montana in Missoula. His research focuses on fundamental fuels characterization using remote sensing, and fire ecology. He received Bachelors and Masters Degrees from Dartmouth College (1990) and The University of Georgia (1994) and completed a Ph.D. in Forestry at University of Montana (2003), where he studied fuel characteristics beneath tree canopies using airborne laser scanning. He remains an active fire practitioner, with 24 years of service in fire management.

### 42. Managing Federal Lands for Resilience to Fire

***Presenter:*** *Platt, Emily, PhD Candidate, Graduate Research Assistant, Oregon State University College of Forestry*
***Additional Author(s):***
*Bailey, John, Associate Professor, OSU College of Forestry*

The success or failure of proactive fire management strategies (e.g. fuels reduction) is based on managers' ability to adequately account for the complexities of both social and biophysical influences. Proactive fire management is as much a social and political process as it is a biophysical process. Decision support tools designed to capture this social-ecological complexity will enhance managers' ability to make good decisions about fire management strategies. Managers must also make decisions in the face of irreducible uncertainty. Uncertainty can lead managers to make decisions with low short-term risk that may have severe long-term consequences. A decision support tool designed to specifically address uncertainty can enable managers to make strategic choices despite unknowns related to climate change, politics, or other influences. Agent-based models are uniquely adapted to address both uncertainty and social-ecological complexity. Uncertainty is addressed through the development of scenarios that represent different possible futures. The relative outcomes of different scenarios can then be compared over time to explore which parts of the system are resilient or vulnerable, or to

answer other key management questions. In addition, agent-based models can link social and biophysical inputs in an integrated model that captures some of the complexity of landscape change. This research uses an agent-based model, Envision, to analyze forest resilience to fire in central Oregon under six different management scenarios. Envision is a GIS-based modeling framework that simulates change on the landscape from both biophysical processes (succession, fire) and social processes (management, social networks). Modeling scenarios for this project are assessed by comparing change in indicators of forest resilience to fire over the course of the scenario. Scenarios explore the effect of management objectives, treatment pattern, treatment unit size, and treatment area on landscape resilience to fire. In addition, modeling scenarios assess change in the proportion of the landscape at risk of stand-replacing fire as weather conditions become more severe. Potential applications for federal land management include use in forest plan revision processes, out-year planning, and fire-shed planning. Agent-based models like Envision may also be useful in developing all lands approaches to forest and fire management.

**Keywords:** resilience, Forest Service, landscape, agent-based model

**Bio:** Emily is a PhD candidate at Oregon State University's College of Forestry where she is studying fire ecology, modeling, restoration, and federal forest policy. Before returning to graduate school, Emily served as executive director of the Gifford Pinchot Task Force where she worked with rural community leaders, Forest Service leaders, and many others to build support for restoration work on national forestlands.

**43. Wildland Fire Smoke: An Overview of Manitoba Health's Emerging Work**

***Presenter:*** *Oshanski, Darlene*

Wildland fires occur regularly throughout much of Manitoba during the months of May to October, and as they are primarily caused by human activity (accidental or intentional) or by lightning strikes, they are often difficult to predict and prevent.

The decision to evacuate residents of a community due to smoke from a wildland fire can be incredibly complex. Before an evacuation can occur, it is critical to assess health risks. As evacuations are inherently disruptive and costly, one should only occur when health benefits outweigh all risks. Unfortunately, scientific evidence regarding the short-term and long-term effects of wildland fire smoke on human health is still limited at this time. However, smoke due to wildland fire events is becoming an ever increasing public health concern.

Manitoba Health and Health Canada have partnered with Environment Canada, to purchase smoke monitors which will assist with the validation process of smoke forecasts emanating from BlueSky (a forecast system that provides wildland fire location, animations of hourly smoke plume trajectories, and ground level concentrations of particulate matter).

Data collected by the smoke monitors will be spatially displayed in Manitoba Health's Common Operating Picture (COP). The COP is an advanced technology tool consisting of geospatial displays and acting as a common repository of information for decision makers.

With more accurate wildland fire smoke forecasting and with the development of a number of smoke related tools, Manitoba Health and Health Canada will target the applicable audiences affected by wildland fire smoke to meet the following objectives;
A) Develop specific smoke event health messaging
B) Develop First Nation messaging for smoke events
C) Examine health outcomes and appropriate messaging for situations when the Air Quality Health Index rises above 10
D) Provide nationally applicable guidance for decision-makers to protect people from wildland fire smoke
E) Examine the combined risks of smoke and heat and develop appropriate messaging for a combination smoke/heat event

By amalgamating these various tools, and aligning them with the above objectives, Manitoba Health and Health Canada is striving to enhance the capabilities for effective risk management and decision making when it comes to population health and wildland fire smoke in Canada.

**Keywords:** wildland fire smoke, health risks, messaging, air quality, forecasts, guidance for decision makers, combined risk

**Bio:** Darlene Oshanski is a recent graduate of the Applied Disaster and Emergency Studies program at Brandon University. She is currently employed by the Office of Disaster Management at Manitoba Health, working as a Special Projects Coordinator. Her interest lies in the area community resiliency building, and the sociology of disaster.

**44. Pollutant Emissions from Large Wildfires in the western United States**

***Presenter:*** *Urbanski, Shawn, Research Physical Scientist, US Forest Service Rocky Mountain Research Station*
***Additional Author(s):***
*Silverstein, Robin, Ecologist, University of Montana*
*Reeves, Matthew, Research Ecologist, US Forest Service Rocky Mountain Research Station*
*Hoa, Wei Min, Research Chemist, US Forest Service Rocky Mountain Research Station*

Large wildfires are a major source of air pollutants in the western United States. Smoke emitted from large wildfires can trigger severe pollution episodes with substantial impacts on public health including increased emergency room visits, hospital admissions, and mortality (Henderson et al., 2012). The magnitude and duration of smoke emissions associated with these events presents significant challenges to air regulators' efforts to meet National Ambient Air Quality Standards (NAAQS) and improve visibility in National Parks and Wilderness Areas as required under the federal Regional Haze Rule. We estimate daily pollutant emissions for multiple large wildfires using a newly developed wildland fuels map and an updated emission factor database. Fuel loading for forests is taken from a new forest fuel classification Fuel Type Groups (FTGs; Keane et al., 2013) which was developed from a large set of USFS Forest Inventory and Analysis surface fuel estimates (n > 14,000). Rangeland fuel loading is estimated with a Normalized Differenced Vegetation Index (NDVI) based biomass product developed using a large set of field data from the USDA Soil Survey Geographic (SSURGO) database, NDVI from the MODIS sensor on the Terra satellite, and landscape attributes (Reeves, 2013). The

significance of the wildfire emissions as a source of NAAQS air pollutants is evaluated with respect to anthropogenic emissions reported in the US EPA National Emission Inventory. We find that when active large wildfires are the dominant source of fine particulate matter PM2.5 and many volatile organic compounds that are precursors for ozone and secondary organic aerosol.

**Keywords:** smoke, wildfires, air quality, emissions

**Bio:** His research tasks are focused on understanding the influence of open biomass burning on the chemistry and composition of the atmosphere. Several aspects of biomass burning are investigated in my research program, including smoke characterization, emission inventories, smoke plume dynamics, and the transport and air quality impact of emissions. Ongoing studies in these areas include: 1) The evaluation and development of biomass burning emission inventory systems 2) airborne and ground based experiments for the validation of smoke dispersion models and atmospheric chemistry transport models, 3) laboratory and field experiments characterizing the gas and aerosol emissions from prescribed burning, 4) the development of satellite based wildfire emission inventories for the western United States.

Shawn earned a B.S. in Meteorology from the University of Oklahoma and a Ph. D. in Atmospheric Sciences from Georgia Institute of Technology

## 45. Does Fuel Reduction Burning Mitigate Wildfire Emission: Evidence from an Empirical Study in Australian Eucalyptus Forest

***Presenter:*** *Volkova, PhD, Luba, Research Fellow, The University of Melbourne, Australia*
***Additional Author(s):***
*Weston Chris, Dr, Senior Lecturer, the University of Melbourne*

Recent field measurements of fuels in south-eastern Australian forests showed that modelled emissions from wild and prescribed fires are likely conservative estimates. Reported emission estimates based on mass loss from fine fuels such as litter and small branches disregard the impact of fire on other fuels including coarse woody debris. In January 2013, a severe wildfire near Aberfeldy of south-eastern Victoria, passed through prescribed burnt area where all fuel strata had been sampled prior to and after prescribed fire three months earlier. We used this opportunity to establish additional study sites in wildfire affected areas to sample remaining fuels. Here we compare impact of high intensity wildfire on fuel treated and long unburnt forest and discuss if emission from prescribed burning can mitigate emission from wildfires

**Keywords:** emission, prescribed fire, wildfire, forest fuels

**Bio:** Dr Luba Volkova is a Research Fellow at the University of Melbourne. She has a PhD in plant ecological physiology from the University of Melbourne, Australia and forest engineering degree from Moscow State Forest University, Russia. Her work experience ranges from forestry consultancy financed by the International Finance Corporation and World Bank to developing national standards for voluntarily forest certification under PEFC umbrella, in latter role she represented Russia at the international arena. In her current role at UniMelb she investigates the impact of fire (prescribed and wild) on forest carbon balance and emission.

### 46. Resolving the Effects of Canopy Structure on Fire-emitted Smoke Dispersion using Large Eddy Simulations

**Presenter:** Chatziefstratiou, Efthalia, PhD candidate, the Ohio State University
**Additional Author(s):**
Kenny, William T, PhD student, the Ohio State University
Heilman, Warren E, Research Meteorologist, USDA Forest Service, Northern Research Station
Bohrer, Gil, Assistant Professor, the Ohio State University

We investigated smoke dispersion from a low intensity fire in canopies of various structures. We used the Regional Atmospheric Modeling System (RAMS)-based Forest Large Eddy Simulation (RAFLES) coupled with the High-resolution VOC atmospheric chemistry in canopies (Hi-VACC) to investigate smoke dispersion from a virtual low intensity fire. Of particular concern to air-quality management are the impacts of fires to air quality. For example, smoke from fires that occur in wildland-urban interface (WUI) areas can linger for relatively long periods of time and have an adverse effect on human health or reduce visibility over roads and highways in the vicinity of and downwind of these fires. Thus, understanding how the atmosphere interacts with these types of fires and the smoke they generate is crucial for fire and air quality management.

In the current work, we used RAFLES and Hi-VACC to investigate how the introduction of a certain amount of heat in forests of different structures influences smoke dispersion in the canopy and above it. We started by simulating the canopy structure of a plot in the Pine Barrens, NJ Forest and prescribing a burn case based on a 2011 prescribed fire led by the US Forest Service. We directly prescribed the heat flux to the bottom three grid layers of the simulation at rates proportional to an assumed fuel load distribution on the virtual forest floor. The mean flux rate was based on observations in the prescribed fire. Next, we changed the canopy structure and investigated the role of canopy structure on smoke dispersion during a low-intensity prescribed fire. We specifically tested how increasing the heat flux during a fire, affects fire distribution in homogeneous and heterogeneous canopy structures, each with homogeneous and heterogeneous fuel loads. The goal is to improve our understanding of the interaction between smoke dispersion and canopy structure in prescribed forest fires by analyzing the differences in smoke dispersion among the simulated cases.

**Keywords:** smoke dispersion, prescribed fire, heat flux, Large-eddy simulation

**Bio:** Mrs. Efthalia Chatziefstratiou graduated with Dipl.-Ing. and and M.Sc. degrees in Civil Engineering from the Aristotle University of Thessaloniki, Greece. She is currently a PhD Candidate in the Department of Civil, Environmental and Geodetic Engineering at the Ohio State University. Her research interests include smoke modeling, biosphere-atmosphere interactions, large-eddy simulations, fire heat flux interactions with atmosphere, atmospheric modeling, fire effects on tree stems, and heat transfer in tree stems.

**47. SmoC and Wildfire Air Quality Response**

***Presenter:*** *Lahm, Pete, Air Resource Specialist, USDA Forest Service*

**Bio:** Pete Lahm is the Air Resource Specialist for the USDA Forest Service, Fire and Aviation Management, in Washington, DC. Starting in 2004, Pete has led the Forest Service's smoke management efforts developing technical approaches and policies related to smoke impacts. Since 2009 he has chaired the National Wildfire Coordinating Group's Smoke Committee. Prior to 2004, Pete managed the Arizona Interagency Air Resource and Smoke Management Program. He chaired the Western Regional Air Partnership's Fire Emissions Joint Forum from 1996-2004. Pete holds a Master's of Environmental Management from Duke University.

**48. Evaluation of Smoke Dispersion Modeling of Large Wildland Fires in WA and ID, 2012**

***Presenter:*** *Rorig, Miriam, Research Meteorologist, USDA Forest Service*
***Additional Author(s):***
*O'Neill, Susan, Research Air Quality Engineer, USDA Forest Service*
*Martinez, Marlin, Universidad del Turabo, Gurabo, Puerto Rico*
*Colon, Joan,Indiana University-Purdue University Indiana (IUPUI)*

The BlueSky Smoke Modeling Framework is a system used to predict PM2.5 concentrations from wildland fire. Currently, the US Forest Service AirFire Team runs BlueSky daily for 5 national and regional scale domains to provide a prediction of smoke impacts across the domain from 24 hrs to 84 hours out into the future. The runs are based on 6 meteorological models and two dispersion model configurations. All runs are automated, with all data downloaded and processed overnight. At the peak of wildfire season, with numerous fires burning throughout the U.S., computing resources are sometimes not sufficient to complete the simulations in a timely fashion. Because of this, BlueSky is typically configured to use models and settings that prioritize efficient run times over optimal results. During September and October 2012, we had a unique opportunity to do multiple BlueSky runs with different meteorological models and dispersion model configurations for several large fires that were generating significant smoke impacts in Washington and Idaho. In addition to the automated CONUS BlueSky runs, the AirFire Team added several custom, Pacific Northwest regional runs to help local and state health and air quality agencies anticipate smoke effects and communicate them to the public. We used different BlueSky configurations, which allowed us to compare different BlueSky outputs for these Pacific Northwest fires. Statistics on maximum and average PM2.5 concentrations, number of grid cells exceeding threshold values, and other metrics for comparison will be presented. In addition, model-predicted PM2.5 will be compared with monitored PM2.5 data. As large wildfire seasons are expected to continue, we need to not only improve our ability to simulate and predict smoke impacts, but to understand the usefulness and limitations of such predictions. This analysis will inform optimal model configuration that balances the need of runtime versus computationally expensive model options, and the implications of those tradeoffs in terms of solution performance.

**Bio:** Miriam Rorig has been a meteorologist with the Pacific Northwest Research Station since 1994, working in the fields of fire weather meteorology and smoke dispersion modeling. Her work has focused on studying dry lightning outbreaks, and generating predicted fuel moistures and fire weather indices using output from meteorological models. She has worked on the development and evaluation of the

BlueSky Smoke Modeling Framework, which is a tool for managing the impacts of smoke from wildland fires. She participates in field studies to collect meteorological an dair quality data, and provides expert smoke model analyses on major wildfire incidences.

**49. Managing burned landscapes: evaluating future management strategies on the Rodeo-Chediski Fire under a warming climate**

***Presenter:*** *Shive, Kristen, Graduate Student Researcher, UC Berkeley*
***Additional Author(s):***
*Fule, Peter Z., Professor, Northern Arizona University*
*Sieg, Carolyn H., Research Plant Ecologist, Rocky Mountain Research Station*
*Strom, Barbara A., Northern Arizona University*
*Hunter, Molly E., Assistant Research Professor, Northern Arizona University*

Climate change impacts on forested ecosystems worldwide include increases in drought-related mortality, changes to disturbance regimes, and shifts in species distributions. Such climate-induced changes will alter the impact of current management strategies, complicating the selection of appropriate strategies to achieve resilient forests. We modeled forest growth in ponderosa pine forests that burned in Arizona's 2002 Rodeo-Chediski Fire using the Forest Vegetation Simulator Climate Extension, where initial stand structures were defined by pre-fire treatment and fire severity. Under extreme climate change, existing forests persisted for several decades, but shifted toward pinyon-juniper woodlands by 2104. Under milder scenarios, pine persisted with reduced growth. Prescribed burning at 10- and 20-year intervals resulted in basal areas within the historical range of variability (HRV) in low severity sites that were initially dominated by smaller-diameter trees, but in sites initially dominated by larger trees the range was consistently exceeded. For all high severity sites, prescribed fire was too frequent to reach the HRV's minimum basal area. Alternatively, for all stands modeled under milder scenarios, uneven-aged management resulted in basal areas within the HRV, because of its inherent flexibility to manipulate forest structures. These results emphasize the importance of flexible approaches to management in a changing climate.

**Bio:** Kristen Shive is a PhD student in the Environmental Science, Policy and Management Department at UC Berkeley. Her current research is focused on post-fire vegetation trajectories in severely burned landscapes in the Sierra Nevada.

**50. Results from modeling the impact of climate change on acreage burned in the U.S. through 2100**

***Presenter:*** *Mills, David, Managing Analyst, Stratus Consulting Inc.*
***Additional Author(s):***
*Russell, Jones, Managing Analyst, Stratus Consulting Inc.*
*Jeremy Martinich, USEPA - Climate Change Division*
*Karen Carney, Managing Scientist, Stratus Consulting Inc.*
*Kate Shouse, USEPA - Climate Change Division*
*Allison Crimmins, USEPA - Climate Change Division*
*Ben DeAngelo, USEPA - Climate Change Division*

We develop and apply methods to quantify and monetize projections of areas burned by wildfires in the contiguous United States under a range of future climates for the period 2000-2100. This national-scale analysis is part of a larger multi-sector project to estimate the impacts of climate change and the benefits of greenhouse gas mitigation. We use the MC1 dynamic global vegetation model to develop our projections of future burned acreage using three climate models that project a range of future conditions using emissions for a reference case and a global greenhouse gas mitigation scenario. Our analysis reveals that mitigation, where global radiative forcing is stabilized at 3.7 W/m2 in 2100, would reduce areas burned across the 21st century by tens of millions of hectares. Monetized, these impacts are equivalent to potentially avoiding billions of dollars (discounted) in wildfire response costs. The magnitude of these results highlights their importance when evaluating climate policy options. However, our results also show that national outcomes are driven by a few regions, and results are not uniform across regions, time periods, or models. We also investigate the sensitivity of future climates to different initial conditions of a climate model to analyze the effect of natural variability, and find significant differences in the nature and timing of results. Collectively, these results raise important questions about how variability in climate projections is accounted for, especially when analyzing impacts, such as wildfires, where extreme or threshold conditions are important.

**Keywords:** climate change modeling, wildfire impacts, economics

**Bio:** David Mills is a Managing Analyst at Stratus Consulting in Boulder, Colorado. Over the past 15 years he has worked to develop qualitative, quantitative, and monetized summaries of the potential environmental and human health impacts of a changing climate. His current project work with respect to climate change impacts on areas burned within the U.S. under future climates was conducted as part of a larger integrated effort managed by the U.S. Environmental Protection Agency to complete a coordinated impacts analysis across multiple sectors using consistent socioeconomic and climate scenarios.

## 51. What Determines Area Burned in Large Landscapes? Insights From a Decade of Comparative Landscape-fire Modelling

***Presenter:*** *Cary, PhD, Geoffrey, Associate Professor, Fenner School of Environment and Society, The Australian National University*
***Additional Author(s):*** *Keane, Robert, Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, Missoula MT, USA.*
*Flannigan, Mike, Professor, Renewable Resources, University of Alberta, Edmonton, Alberta, Canada.*
*Davies, Ian, PhD Scholar, Fenner School of Environment and Society, The Australian National University, Canberra, ACT, Australia.*
*Li, Chao, Research Scientist, Canadian Forest Service, Edmonton, Alberta, Canada.*
*Parsons, Russ, Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, Missoula MT, USA.*
*And participants in three international landscape-fire model comparisons*
*Named authors are the core group of scientists involved in coordingating this research over the last ten years. Other "participants in three international landscape-fire model comparisons" are very numerous, made important but less frequent contributions.*

Understanding what determines area burned in large landscapes is critical for informing wildland fire management in fire-prone environments and for representing fire activity in Dynamic Global Vegetation Models. For the past ten years, a group of landscape-fire modellers have been exploring the relative influence of key determinants of area burned in temperate, forested landscapes using a suite of landscape-scale fire models from around the world. Three major simulation experiments have been completed thus far, each incorporating at least five models and examining several different factors, including fuel management, weather variability, climate change and landscape attributes. The first experiment found that variation in weather and climate was more important in determining simulated area burned than variation in fuel-load pattern and terrain in the majority of models. Subsequently, the second experiment found that year to year variation in weather and efforts to reduce ignitions had a greater impact on area burned than fuel management in the range of modelled ecosystems. Finally, the third experiment explored the relative importance of vegetation dynamics, along with variation in climate and weather from previous experiments, in determining area burned. In this case, variation in climate was found to be the critical factor, indicating a key outcome for wildland fires with future climate change. Similar to the concept of the “wisdom of crowds”, the multiple-model perspective gained through these efforts provides considerable insights into examining commonalities across a range of ecosystems and simulation models.

**Keywords:** Wildland fire, Modelling, Climate change, Fuel management, Model comparison

**Bio:** Dr Geoff Cary is an Associate Professor at The Australian National University. His research interests include evaluating fire management and climate change impacts on fire regimes using landscape-scale simulation modelling, ecological investigations of interactions between fire and biota, and empirical analysis of house loss in catastrophic wildland fires. Geoff co-leads an international group of landscape-fire modellers, is a member of the Editorial Advisory Committee for the International Journal of Wildland Fire, was recently a project leader in the Bushfire CRC, and was a member of the Australian Capital Territory Bushfire Council and New South Wales Parks and Wildlife Advisory Council.

**52. Severity and Associated Climate Conditions of Large Fires Diverge from Historical Precedent in High-Elevation Forests in the Pinaleño Mountains, Arizona, U.S.A**

***Presenter:*** *O'Connor, PhD, Christopher, Postdorctoral Research Associate, School of Natural Resouces & the Environment, University of Arizona*
***Additional Author(s):***
*Lynch, Ann M., Research Entomologist, US Forest Service, Rocky Mountain Research Station*
*Donald A. Falk, Associate Professor, School of Natural Resources & the Environment, University of Arizona*
*Swetnam, Thomas W., Director and Professor, Laboratory of Tree-Ring Research, University of Arizona*

We compare the severity and spatial and temporal patterns of contemporary fires in the ponderosa pine, mixed-conifer, and spruce-fir forests of the Pinaleño Mountains in southeast Arizona to those of dendrochronologically-reconstructed historical fires in order to evaluate whether recent large high-severity fires are within or outside the historical range of variability in terms of frequency, severity, spatial extent, and association with climate conditions. We use a gridded fire scar and tree demography sampling network for forests above 2,135 m elevation (ponderosa pine, mixed-conifer, and spruce-fir vegetation types) to reconstruct temporally- and spatially-explicit estimates of fire extent, burn severity, and tree demographics, as well as climate associations of fires from individual site to landscape scales from 1640 to 2008 c.e. We found that a) fire exclusion beginning in the 1880s led to a significant reduction in fire spread but not fire ignition; b) contemporary fires are more severe than similarly sized fires prior to fire exclusion; and c) pre-fire exclusion large fires were associated with extreme drought following one or more wet years and tended to burn with low to moderate-severity; contemporary fires occurred during moderate drought without antecedent wet conditions at moderate to high burn severity. These changes to severity, spatial patterns, frequency, and climate associations of spreading fires after 1880 suggest that continuity of horizontal and vertical fuels no longer limits fire spread, and moderate drought and an ignition source are now sufficient for mixed- and high-severity fire to spread in these dry fuel-saturated forests.

**Keywords:** dendrochronology, multi-century, landscape scale, fire severity, drought, fire exclusion

**Bio:** My work in the Pinaleños focused on spatial and temporal dendrochronological reconstructions of complex interactions between forest tree population dynamics, fire, insect outbreaks, climate, and human land use practices. My postdoctoral work addresses the effects of climate change on forest ecosystems and associated risks of fire and insect outbreaks on a series of military reservations throughout the southwest United States. This work relies on a series of spatially-explicit vegetation and fire simulation models informed by past disturbance histories and current vegetation parameters.

**53. Fuel moisture sensitivity to temperature and precipitation; Climate change implications**

***Presenter:*** *Flannigan, Mike, Professor, University of Alberta, Department of Renewable Resources, Edmonton, AB, T6G 2H1, Canada*
***Additional Author(s):***
*B.M. Wotton; Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste Marie, ON, P6A 2E5, Canada.*
*G.A. Marshall; University of Alberta, Department of Renewable Resources, Edmonton, AB, T6G 2H1, Canada*
*W.J. de Groot; Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste Marie, ON, P6A 2E5, Canada.*
*J. Johnston; Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste Marie, ON, P6A 2E5, Canada.*
*N. Jurko; Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste Marie, ON, P6A 2E5, Canada*

The objective of this paper is to examine the sensitivity of fuel moisture to changes in temperature and precipitation. We use the Canadian Forest Fire Weather Index System components to represent the fine fuel moisture content (FFMC), the duff moisture content (DMC) and the moisture content of deeper organic soils (Drought Code, DC). We obtained weather data from 12 stations across Canada for the fire season during the 1971-2000 period and with these data we created a set of modified weather streams from the original data by varying the daily temperatures by 0 to +5°C in increments of 1°C and the daily precipitation from -40% to +40% in increments of 10%. The fuel moistures were calculated for all the temperature and precipitation combinations. When temperature increases we find that for every degree of warming, precipitation has to increase by more than 10% for FFMC, about 10% for DMC and about 5% for DC to compensate for the warming in terms of fuel moisture. Also, we found in terms of

days of above FFMC of 91, a critical value for fire spread, that no increase in precipitation could compensate for a temperature increase of 1°C. Results from GCMs suggest that the implications of this sensitivity to temperature increases suggest that the future will have drier fuels and a higher frequency of extreme fire weather days.

**Bio:** Dr. Mike Flannigan is a professor with the Department of Renewable Resources at the University of Alberta. He received his BSc (Physics) from the University of Manitoba, his MS (Atmospheric Science) from Colorado State University and his PhD (Plant Sciences) from Cambridge University. Dr. Flannigan's primary research interests include fire and weather/climate interactions including the potential impact of climatic change, lightning-ignited forest fires, landscape fire modelling and interactions between vegetation, fire and weather. He was the Editor-in-Chief of the International Journal of Wildland Fire (2002-2008) and has taken on leadership roles with the US National Assessment on Global Change, IPCC, IGBP Fire Fast Track Initiative and Global Change Terrestrial Ecosystems (GCTE) efforts on the global impacts of fire. Mike is the director of the Western Partnership for Wildland Fire Science located at the University of Alberta.

**54. Possible mechanisms for increased tree mortality resulting from altered interactions between fire and other disturbances**

***Presenter:*** *Kane, PhD, Jeffrey, Assistant Professor, Humboldt State University*
***Additional Author(s):***
*van Mantgem, Phillip J.,Research Ecologist, United States Geological Survey*
*Varner, J. Morgan, Assistant Professor, Mississippi State University*
*Metz, Margaret, Postdoctoral Researcher, University of California, Davis*

Interactions between fire and other disturbances (e.g. insects, disease, and drought) have long influenced forest dynamics in much of the western U.S. However, increasing temperatures concurrent with other human-mediated changes have resulted in the increased frequency, size, and severity of fire in many forest types. These changes alone and in combination with other disturbances have the potential to synergistically increase tree mortality. However, there is still much debate about the mechanisms and magnitude of these synergisms among disturbances. To help inform this debate, we review available studies on disturbance interactions in fire-prone forests of the western U.S. and provide a conceptual overview on the possible mechanisms that could drive increased tree mortality. Based on our review, we determined that the synergistic increase in tree mortality is influenced by following factors: 1) types of interactions, 2) order of disturbances, 3) initial disturbance severity, 4) time between disturbances, and 5) novelty of the interaction. To support our findings, we provide examples from published research highlighting possible mechanisms for increased tree mortality through disturbance synergisms. For instance, higher tree mortality risks resulted from exposure to drought prior to fire, independent of fire intensity. In another study, increased redwood (Sequoia sempervirens) mortality following fire was observed in areas recently infected with Phytophthora ramorum. These and other examples suggest that synergistic increases in tree mortality will be context dependent, varying across spatial and temporal scales. However, determining the mechanisms that drive synergistic increases in tree mortality will be required to determine the actions needed to minimize the negative ecological impacts of these altered interactions.

**Keywords:** disturbances, fire, interactions, synergisms, tree death, tree mortality

**Bio:** Jeff Kane is an Assistant Professor of fire ecology and fuels management at Humboldt State University in the Department of Forestry and Wildland Resources and Director of the HSU Wildland Fire Laboratory. His research interests are broadly in fire ecology, disturbance ecology, fuels management, and conservation biology.

**55. Public and agency perceptions about smoke: Interview and survey results from four states**

***Presenter:*** *Olsen, PhD, Christine, Fire Social Scientist, Oregon State University*
***Additional Author(s):***
*Toman, Eric, Assistant Professor, The Ohio State University*
*Frederick, Stacey, Research Assistant, Oregon State University*
*Mazzotta, Danielle, Central Idaho Associate, Idaho Conservation League*

Smoke is a growing concern for communities as well as land and air quality managers. It affects air quality across landscapes much larger than the originating fire and can have significant negative impacts on nearby communities. In early 2013, the U.S. Environmental Protection Agency (EPA) lowered ambient air quality standards for particulate matter which will likely result in more communities struggling to meet EPA limits as a result of smoke. At the same time, wildfires seem to grow in number and size every year, producing major smoke impacts on some communities, and underscoring the need to reduce fuels on unburned landscapes to reduce the risk of future fire events. Managers and landowners wishing to use fire as a tool for fuel reduction (i.e., prescribed fire, pile burns) could face significant barriers, both because of air quality standards and because of public concern for smoke impacts. Accordingly, it is important to understand public beliefs regarding smoke, especially focusing on what factors may influence acceptance of smoke emissions.

In this presentation we present findings from the first two stages of a three-stage project funded by the Joint Fire Science Program and the Western Wildland Environmental Threat Assessment Center (WWETAC). Phase one included interviews conducted in 2011 in south-central Oregon, northwest Montana, northern California and central-coast of South Carolina among forest and fire managers, air quality regulators, and some community group members. This presentation will focus on the major challenges identified by interview participants regarding smoke management, and communication strategies that were identified as useful for overcoming these challenges. Phase two of this project included a public mail survey conducted in 2012 in the same four locations. This presentation will provide an overview of survey results as well as focused information on factors that may influence tolerance for smoke. Each origin of smoke emissions is treated separately to help define the different opinions associated with different types of fires. Results will be discussed cumulatively across all sites with specific implications for large wildfires.

**Bio:** Christine Shaw Olsen, Ph.D., is a Research Social Scientist and Instructor in the Department of Forest Ecosystems & Society at Oregon State University in Corvallis, Oregon. Dr. Olsen is co-investigator of the Northwest Fire Science Consortium and conducts research on citizen-agency interactions, public opinions about fire and fuel reduction activities, and communication and education about forestry and fire. Her most recent projects examine public perceptions of smoke, citizen-agency trust, and coupled human-natural systems in fire-prone landscapes. Dr. Olsen teaches classes about forest management for multiple resource values, managing in the wildland-urban interface, sustainable natural resource management, and social science methods.

**56. Understanding the effect of large wildfires on residents' well-being: What factors influence reported wildfire impact?**

***Presenter:*** *Paveglio, PhD, Travis, Assistant Professor, University of Idaho*
***Additional Author(s):***
*Kooistra, Chad, graduate student, University of Idaho*
*Hall, Troy, professor, University of Idaho*

Existing wildfire social science has indicated that wildfires can impact the short and long-term functioning of social systems (e.g. economic vitality, disruption of services, risk perceptions). Less work has focused on how wildfire events affect the well-being of individual residents impacted by such events. Wildfire factors that could influence resident well-being include individual and collective impacts, such as the degree of immediate impact to one's life and property, or perceptions of biophysical characteristics, including the number of simultaneous ignitions, rapidity of fire spread, and intensity or duration of smoke. Perceptions of these impacts and others can vary among individuals. In this study we explore the extent to which perceptoins of biophysical characteristics and personal- or community-level impacts of wildfires influence residents' self-reported well-being following the event. To answer this question we surveyed residents in Washington, Oregon, Idaho and Montana who were potentially impacted by 25 wildfires. We used a GIS procedure and existing spatial data sets to select the 25 wildfires that: (1) occurred during 2011 or 2012; (2) were larger than 1,000 acres; (3) and were within 15 kilometers of a populated area. Populated areas were determined using Census designations and all fires selected for study intersected forested ecoregions. We drew random samples of 220 individuals from within and up to 15 kilometers from each fire perimeter selected for study. A hybrid internet and mail survey was used to implement the survey following the Dillman method. We received 834 completed surveys, for a 17% response rate. Respondents were asked a number of questions related to the specific fire that occurred in their locality, including perceptions about the typicality of the event, their perception of wildfire suppression effectiveness or their attachment to the landscape. They were also asked about personal or community impacts from the fire. The dependent measure of well-being was a composite set of Likert-scale questions. Hierarchical linear modeling was used to identify factors predicting the impact of fires on individuals (level 1) and whether those factors differ by fire (level 2). Initial results suggest that both impacts to social dynamics and perceptions of biophysical extremity contribute to reported well-being of residents following wildfires. Results from this study could improve wildfire impact assessment and aid in prioritizing community recovery during fires. They could also help fire managers and community planners prioritize their mitigation or operation strategies in ways that minimize community impacts from wildfire.

**Keywords:** resident well-being; perceptions; impact; human communities

**Bio:** Paveglio's research focuses on wildfire, environmental hazards, and natural resource management. This includes the adoption of mitigation activities, development of natural resource policy, communication of risk information, and conflict or collaboration about natural resource management. His research also focuses on the communication of emerging scientific information to resource managers or the public and how that information leads to action. Paveglio has received training in communication, ecology, sociology, natural resource policy and Geographic Information Systems (GIS). He uses that interdisciplinary background to address complex natural resource issues with a wide variety of research partners.

**57. Local Ecological Knowledge and Fire Management: What Does the Public Understand?**

***Presenter:*** *Diaz, John, Graduate Assistant, North Carolina State University*
***Additional Author(s):***
*Steelman, Toddi, Executive Director and Professor, University of Saskatchewan*
*Nowell, Branda, Associate Professor, North Carolina State University*

As fire management agencies seek to implement more flexible fire management strategies, local understanding and support of these strategies becomes increasingly important. This study used survey data and key informant interviews from four 2010 large wildland fires to understand how local ecological knowledge and education level affected local fire management perception and understanding. Results indicated that local ecological knowledge was associated with local understanding of fire management strategies. Education levels were not significantly related to public perception of fire management but were related to higher proficiencies in accurately identifying local ecological conditions. Education may play a mediating role in understanding complex environmental issues but does not predict better understanding of fire management.

**Keywords:** local ecological knowledge; fire management; forest-related conditions

**Bio:** John started working on the wildland fire research in the spring of 2011 as a research assistant for North Carolina State University (NCSU) Fire Chasers and the Southern Fire Exchange. John managed field research efforts and developed a comprehensive multimedia marketing strategy to increase public knowledge of prescribed fire. John has two B.S. degrees from NCSU (Environmental Technology and Management and Science, Technology and Society), a M.S. in Natural Resources with a technical concentration in Policy and Administration and is currently in the Department of Forestry and Environmental Resources at NCSU working on his PhD. in Forestry and Environmental Resources.

**58. Community Wildfire Protection Planning in Large-Fire Landscapes: An Analysis of Plan Content**

***Presenter:*** *Abrams, PhD, Jesse, Postdoctoral Research Associate, Ecosystem Workforce Program, University of Oregon*
***Additional Author(s):***
*Nielsen-Pincus, Max, Ph.D., Assistant Professor of Environmental Science, Portland State University*
*Paveglio, Travis, PhD, Assistant Professor of Communication, Washington State University*
*Moseley, Cassandra, PhD, Director, Ecosystem Workforce Program, University of Oregon*

The 2003 Healthy Forests Restoration Act (HR1904) created new authorities for fire-prone human communities, empowering them to create community wildfire protection plans (CWPPs). These plans were envisioned as means for at-risk communities to collaboratively identify and prioritize values at risk, resources, and action steps to protect people, property, and critical infrastructure on a site-specific basis. Within these plans, communities define the values at risk from wildfire, establish the boundaries of their respective wildland-urban interface areas, set management priorities for fire protection, and

specify strategies to increase local communication, emergency response capacity, and coordination among firefighting agencies and local governments. While over 14,000 CWPPs have been completed nationwide, to date there have been no systematic analyses of plan content. We used a database of large wildfires occurring between 2004 and 2011 to identify 113 relevant CWPPs from ten western states which were subsequently coded for attributes related to plan metadata, integration with other planning frameworks, the planning process itself, risk assessment, plan content, and implementation strategies. We present here our analysis of these coded plans, emphasizing patterns related to recommended management actions, implementation steps, and key wildfire protection planning elements. We consider the significance of an underlying homogeneity across plans in the distribution of roles and responsibilities and key protection strategies. We also analyze the extent to which the inclusion of professional consultants in the planning process affects plan outcomes. This study points the way toward further questions regarding the role of local and non-local entities in fostering the development of fire-adapted communities.

**Keywords:** Planning; Community-Based Forestry; Policy; Governance

**Bio:** Jesse Abrams studies environmental governance in rural communities, with a focus on the American West. His past research has focused on private land management in communities experiencing amenity migration, fire and forest management perceptions in fire-prone areas, and the role of community capacity and leadership in effective environmental governance. He currently has research endeavors in the American West, Midwest, and Latin America.

**59. Forest Jihad?: The Threat of Religious-Inspired Pyro-Terrorism in U.S. Forests and Abroad**

> ***Presenter:*** *French, Diane, M.A. Candidate, Johns Hopkins University Paul H. Nitze School of Advanced International Studies (SAIS)*

While modern-day security policies largely focus on the threat of weapons of mass destruction (WMD) in urban areas, the so-called “War on Terror” has also brought a new threat to Western soil – “forest jihad,” or the religious-inspired use of pyro-terrorism in forested landscapes and wildland-urban interface regions. The United States is no stranger to fire wars and arson attacks in forested areas, having been both the target and executor of such tactics during World War II and the Vietnam War, respectively. More recently, however, the U.S. has been the target of individual acts of arson by non-state organizations and individuals pursuing political, social and religious aims. This new wave of pyro-terrorism has been most frequently carried out by domestic environmental activists, yet evidence points to an increasing threat from radical Islamic fundamentalist organizations, such as al Qaeda, seeking retaliation for the presence of American and allied troops in Iraq and Afghanistan. Indeed, when Navy SEALs killed Osama bin Laden in 2011, they captured numerous al Qaeda plans including a detailed campaign for starting fires throughout the American West. One year later, al Qaeda’s online English-language magazine, Inspire, published an article titled “It is of your freedom to ignite a firebomb,” which offers detailed advice for starting large forest fires in the U.S. with nothing more than a timed explosive device. Not only do such strategies require minimal cost, coordination and effort, forests provide a logical and vulnerable target due to the potential for large-scale physical, economic and psychological destruction; the sustained timescale and range of impact of wildfires; the impossibility of thoroughly protecting large, forested lands; the challenge of coordinating a concerted response from multiple accountable authorities; and the difficulty of such authorities to successfully determine not only the cause, but the perpetrator, of the incident. Throughout the last decade, incidents and evidence of forest-based pyro-terrorism have been publically acknowledged in Israel, Spain, Greece, Estonia, Australia, and the U.S. With destructive force rivaling that of a nuclear weapon, and compounded environmental consequences for deforestation and climate change as well as political, social, psychological and economic effects, wildfires deserve a more prominent position in the national security dialogue and doctrine of the U.S. and her allies. The threat of forest jihad necessitates enhanced coordination in wildfire response and prevention tactics, as well as an overarching change in mindset to frame such incidents as national security threats, rather than simply land-management issues.

**Keywords:** Pyro-terrorism, forest jihad, fire war, arson, wildland-urban interface, national security, War on Terror, al Qaeda, weapon of mass destruction (WMD)

**Bio:** Diane French is a student at the Johns Hopkins University Paul H. Nitze School of Advanced International Studies (SAIS) in Washington, DC, where she is pursuing a Master of Arts degree in International Relations and International Economics with a concentration in Energy, Resources and Environment. She received a Bachelor of Arts degree in Politics from Princeton University ('12), where she concentrated in International Relations and obtained a certificate degree in Near Eastern Studies. Prior to attending graduate school, she worked in the White Mountain National Forest of New Hampshire and the 100-Mile Wilderness of northern Maine with the Appalachian Mountain Club, the nation's oldest outdoor recreation and conservation organization. She hopes to combine her passion for the outdoors with her background in security studies to pursue a career in Environmental Security.

**60. Assessing the Efficacy of Community Wildfire Protection Plans in Colorado**

***Presenter:*** *Lyon, Katie, Ph.D. Student, Colorado State University*
***Additional Author(s):***
*Vaske, Jerry J., Professor, Colorado State University*

Rapid population growth and suburban development in Colorado places more and more people and buildings within areas that can burn in large wildfires. The potential consequences of large wildfires can be devastating and costly, thus require effective planning and mitigation. The Healthy Forests Restoration Act of 2003 (HFRA) encourages communities to engage in comprehensive forest health planning and prioritization of mitigation activities by developing community wildfire protection plans (CWPPs). The planning process brings together diverse local interests to discuss their mutual concerns for public safety, community sustainability and natural resources. Currently, more than 200 Community Wildfire Protection Plans (CWPPs) have been developed in Colorado; several are county-level plans, while others are community-level plans that apply to one or more subdivisions or HOAs. A small number of CWPPs have been fully implemented while the remainder are in various stages of implementation. It is essential to assess the effectiveness of these efforts in bringing together communities to reduce fire risk. It also is important to understand the barriers that prohibit participation and implementation. This paper synthesizes findings from an assessment of all Colorado CWPPs. Specifically, this paper will discuss how the scale of the plan (i.e., county-wide, fire protection district or subdivision level CWPPs) impacted community involvement and mitigation work completed.

**Keywords:** collaboration, effectiveness, mitigation, planning

**Bio:** Katie Lyon is a Ph.D. student in Human Dimensions of Natural Resources at Colorado State University. Her research focuses on how communities and individual homeowners prepare for wildfire.

**61. Effects of contemporary and future fire management on carbon balance in the Greater Yellowstone Ecosystems evaluated with remote sensing and modeling**

***Presenter:*** *Zhao, Feng, University of Maryland, College Park*
***Additional Author(s):***
*Zhu, Zhiliang, Physical Scientist, U.S. Geological Survey*
*Huang, Chengquan, Associate Research Professor, University of Maryland, College Park*

Fire management has a large potential to alter regional carbon fluxes – notably by way of greenhouse gas emissions and fuel removals. Here we use a combination of remote sensing and forest modeling to track the changes in different carbon pools in the past decades, with particular attention to land ownerships since fire management differ widely between national parks and wilderness area (NPWA) and national forests (NFs). Extensive studies have been carried out to study past fire activities including the 1988 Yellowstone fire in the greater Yellowstone ecosystems (GYE) (Turner et al. 1997, Hansen et al. 2000, Turner et al. 2003). These studies relied on plot level data and offered evidence of fire effects on the carbon cycle in GYE. In this study, we used long time-series remote sensing combined with forest modeling to calculate C stocks in NPWA and neighboring NFs, and investigated carbon consequences of fire management activities in the GYE, especially on the occurrences of big fires. Burn scar and severities were derived from the Monitoring Trend of Burn Severity (MTBS) database as well as fire record collected from local NPWA and NFs offices. These fire data were used as input to the Forest Vegetation Simulator (FVS) to estimate carbon released from previous fires (since the 1970s) and carbon balance over time. The FVS model was also used to simulate future forest structure and carbon dynamics based on alternative fire management plans developed by local NPWA and NFs under different climate change scenarios. Preliminary results indicate that under certain climate change scenario and the current management policy, the GYE region could stock more C in the near future, gradually increasing from 5.8 × 1014 g C in the 2000 baseline to about 7.7 × 1014 g C in the year 2050. More detailed analysis will be presented during the conference.

Hansen, A. J., J. J. Rotella, M. P. Kraska, and D. Brown. 2000. Spatial patterns of primary productivity in the Greater Yellowstone Ecosystem. Landscape Ecology 15:505-522.
Turner, M. G., W. H. Romme, R. H. Gardner, and W. W. Hargrove. 1997. Effects of fire size and pattern on early succession in Yellowstone National Park. Ecological Monographs 67:411-433.
Turner, M. G., W. H. Romme, and D. B. Tinker. 2003. Surprises and lessons from the 1988 Yellowstone fires. Frontiers in Ecology and the Environment 1:351-358.

**Keywords:** Greater Yellowstone, C Cycle, Fire management

**Bio:** Feng Zhao is a PHD student and research assistant in the Department of Geographical Sciences, University of Maryland, College Park.

### 62. Determining Relative Contributions of Vegetation and Topography to Burn Severity from LANDSAT Imagery

***Presenter:*** *Wu, Zhiwei*

Fire is a dominant process in boreal forest landscapes and creates a spatial patch mosaic with different burn severities and age classes. Quantifying effects of vegetation and topography on burn severity provides a scientific basis on which forest fire management plans are developed to reduce catastrophic fires. However, the relative contribution of vegetation and topography to burn severity is highly debated especially under extreme weather conditions. In this study, we hypothesized that relationships of vegetation and topography to burn severity vary with fire size. We examined this hypothesis in a boreal forest landscape of northeastern China by computing the burn severity of 24 fire patches as the difference between the pre- and post-fire Normalized Difference Vegetation Index obtained from two Landsat TM images. The vegetation and topography to burn severity relationships were evaluated at three fire-size levels of small (<100 ha, n=12), moderate (100–1,000 ha, n=9), and large (>1,000 ha, n=3). Our results showed that vegetation and topography to burn severity relationships were fire-size dependent. The burn severity of small fires was primary controlled by vegetation conditions (e.g., understory cover), and the burn severity of large fires was strongly influenced by topographic conditions (e.g., elevation). For moderate fires, the relationships were complex and indistinguishable. Our results also indicated that the pattern trends of relative importance for both vegetation and topography factors were not dependent on fire size. Our study can help managers to design fire management plans according to vegetation characteristics that are found important in controlling burn severity and prioritize management locations based on the relative importance of vegetation and topography.

**Keywords:** Burn severity; Vegetation; Topography; Fire size; NDVI; Fire management

**Bio:** Zhiwei Wu: Male, born in 1982, PhD, Assistant professor of the institute of applied ecology, Chinese Academy of Sciences. His research interests include fire ecology, landscape ecology, and forest landscape modeling. He has published more than 15 papers science 2011.

### 63. Influences of Previous Wildfires on Subsequent Fire Severity, Vegetation Change and Resilience in a Reburned Southwestern Landscape

***Presenter:*** *Coop, PhD, Jonathan, Assistant Professor, Western State Colorado University*
***Additional Author(s):***
*Holsinger, Lisa, Ecologist, Aldo Leopold Wilderness Research Institute*
*McClernan, Sarah, Student/Field Technician, Western State Colorado University*
*Parks, Sean, Landscape Ecologist, Aldo Leopold Wilderness Research Institute*

Land use legacies coupled with recent drought have transformed fire regimes across much of the southwestern U.S., where increasingly severe and extensive fires are driving rapid and pronounced changes across many once-forested landscapes. In the wake of such fires, vegetation succession and subsequent reburning have the potential to create feedbacks reinforcing both altered fire regimes and changed ecological communities, rather than restoring systems toward pre-settlement condition.
In the eastern Jemez Mountains of New Mexico, portions of four large burns, La Mesa (1977), Dome (1996), Oso (1998), and Cerro Grande (2000) were reburned by the 63,000-ha Las Conchas fire (2011).

How did the severity of these previous wildfires influence vegetation prior to Las Conchas, the severity of the Las Conchas reburn, and ensuing vegetation change and recovery? We addressed these questions using a combination of remotely sensed measures of fire severity and field-sampled vegetation data.

Prior to the Las Conchas fire, previous burns showed pronounced structural and compositional differences compared to unburned areas, including reduced conifer canopy cover, expanded cover by resprouting shrubs, and increased native and introduced grasses. Las Conchas fire severity was strongly reduced within in these previous burns. Relationships between previous burn severity, vegetation structure, and Las Conchas burn severity suggest that 1) where previous fires burned at low severity, they created or maintained fuel structures that subsequently burned at low severity, 2) this effect diminished over time, probably due to regrowth of subcanopy woody vegetation, and 3) where previous fires had burned at high severity, Las Conchas fire severity was highly variable, depending on succession to woody or non-woody vegetation types. Comparisons of pre- and post-Las Conchas vegetation indicate that overall, reburning reinforced effects of previous fires on vegetation composition. However, vegetation resilience (as measured by changes in composition, cover, and richness) to the Las Conchas fire was also enhanced in previous burns—communities that had prior exposure to high severity fire showed more rapid recovery toward pre-Las Conchas composition and cover. These findings have implications for fire and fuels management and post-fire rehabilitation strategies.

**Keywords:** dNBR, fire severity, Gambel's oak, Las Conchas, ponderosa pine, reburn, Southwest

**Bio:** Jonathan Coop's research and teaching interests revolve around applied ecology, conservation, and restoration of plant species, communities, and landscapes in the southern Rocky Mountains. Themes include how disturbance regimes, climate, and abiotic gradients interact to shape diversity, community composition, and landscape dynamics; human influences on all of the above; and management for a future of certain change of uncertain direction and magnitude. His favorite study sites kept burning down, so he developed an interest in fire.

### 64. Comparison of Six Fire Severity Classification Methods Using Fires From Montana and Washington, USA

***Presenter:*** *Sikkink, PhD, Pamela, Biological Scientist, US Forest Service RMRS Forest and Woodland Ecosystems*

Fire severity classifications are used in the post-fire environment to describe specific fire effects, such as soil alteration or fuel consumption on the forest floor. Usually severity classifications have been developed to describe specific effects, locations, or variables, making efforts to compare fire severity classification methods derived from different methods seem unimportant. However, with many classifications in use and very diverse effects to classify, it is important to determine how a particular method classifies severity and whether choice of classification method matters for restoration, ecology, or economic considerations. The objective of this study was to determine how well the classes obtained from six different classification methods agreed with each other and how severity classes derived from each method compared with a standard field assessment for fire severity that is commonly used in the United States.

Comparisons of fire severity classes were made on 289 field plots from 15 fires across Montana and Washington using (1) a fire severity matrix (Ryan and Noste 1985); (2) soil post-fire indices (Jain and others, 2012); (3) the Monitoring Trends in Burn Severity (MTBS) classification (www.mtbs.gov),; (4) a modification of the relativized differenced normalized burn ratio (RdNBR) classification for plots in Washington; (5) the Burned Area Emergency Rehabilitation (BAER) classification); and (6) classes created by a simulation model developed by Keane and others (2010). The classifications derived from these six methods were compared to on-site assessments of fire severity classified with the Composite Burn Index (CBI), which is a standard field severity assessment measure that is widely used in the United States. It was found that none of the classifications from the six methods adequately represented the fire effects and severity observed and recorded in field plots sampled with CBI. When the methods were compared among themselves for consistency of classes, the same severity class was obtained only 30% of the time. Even the three remote-sensing methods agreed only slightly better than 30% among their classes. A prototype classification system that was developed by Sikkink and Keane (2013) focused on objectively relating fuel consumption, fuel moisture, fire intensity, fire residence time, and soil heating to the classification process. This prototype significantly improved agreement between CBI and the fire severity class at each of the study locations.

**Keywords:** fire severity classification, Montana, Washington

**Bio:** Pamela Sikkink currently works in masticated fuels research for the Rocky Mountain Research Station Forest and Woodland Ecosystems Program in Moscow, Idaho. Prior to this position, she was employeed by the Missoula Fire Sciences Lab in Missoula, MT, where she worked on fire severity research for the FIRESEV project.

### 65. The Influence of Interacting Gradients in Wilderness Management, Spatial Climate, and Topography on Fire Severity in the Northern Rocky Mountains USA

***Presenter:*** *Miller, Carol, Research Ecologist, Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, USDA Forest Service*
***Additional Author(s):***
*Haire, Sandra; Research Landscape Ecologist; Haire Laboratory for Landscape Ecology*

Determining the influence of land management on fire effects is complicated by interacting factors that vary in space and time. First, fire severity can be linked to climate conditions, including long term drought, as well as weather conditions during burning. Second, topography and fuels influence ignition locations, fire spread, and fire intensity, all of which influence outcomes of individual fire events. Last, and importantly, various fire and land management practices preceding and during a fire event can influence fire effects. Unfortunately, comprehensive records that quantify where and when various management strategies occurred are not available at regional scales. Aware of these challenges, we designed a study of fires occurring from 1984- 2010 to examine variability in fire severity along a "wilderness gradient" in the Northern Rockies, a study region that includes several wilderness areas with policies which allow for natural burning. We constructed the gradient to reflect our expectation that fire severity in wilderness interiors, or core areas, had the greatest likelihood of being influenced by natural burning practices. Using the Landsat change detection algorithm, ΔNBR, we characterized fire severity for individual fire events randomly distributed across the wilderness gradient. We used quantile regression to quantify limits to severity imposed by a suite of climate variables, topographic roughness, and the wilderness gradient. Our results indicated that although relatively more large fires occur in wilderness interiors, these fires burn less severely than those located toward the non-wilderness end of the gradient. Moreover, model comparisons indicated that climatic and topographic factors are predominant influences on the severity of fires across landscapes in the Northern Rockies, regardless of location along the wilderness gradient. Our findings underline the importance of unique climatic, topographic, and ecosystem characteristics of the region as a useful context for understanding the dynamics of fire severity in relation to management.

**Keywords:** fire severity, wilderness, natural fire regimes

**Bio:** Carol Miller earned a Masters degree in Forest Science and a PhD in Ecology, both from Colorado State University. As a graduate student, she developed and used a simulation model to study the interactions among climate, fire, and forest pattern in the Sierra Nevada of California. As a Research Ecologist with the Aldo Leopold Wilderness Research Institute in Missoula, MT, her program of research seeks to help land managers understand how to include wildland fire as an ecological process to landscapes.

**66. Are spatial patterns of burn severity changing with warming climate and increasing wildfire?**

***Presenter:*** *Harvey, Brian, PhD candidate, University of Wisconsin, Madison*
***Additional Author(s):***
*Donato, Daniel C., Natural Resource Scientist, Washington State DNR*
*Turner, Monica G., Professor, University of Wisconsin*

The last three decades have seen a sharp rise in wildfire activity across the western US (e.g., number of large fires, total area burned), but little is known about how spatial patterns of wildfire may also be changing (e.g., patch size and shape of severe [stand-replacing] fire). Spatial heterogeneity of burn severity is ecologically important, particularly in areas of stand-replacing wildfire where the burn mosaic creates patterns, such as distances to seed source, which can affect post-fire forest reestablishment. Anecdotal reports have suggested that recent wildfires are burning with more homogenous patterns of large, severe burn patches, but little research has tested for changes in the spatial heterogeneity of burn severity over time and space.

We used a spatially extensive network of post-fire field measurements (n = 371 plots) and satellite measures of burn severity (RdNBR) to generate maps of stand-replacing fire (> 90% of pre-fire live tree basal area was killed by fire) for all forested areas in the Northern Rockies (USA) from 1984 to 2010. We used these field-calibrated maps to test for changes over time in landscape metrics of stand-replacing fire. Specifically, we asked whether the composition (e.g., proportion that burned as stand-replacing) and configuration (e.g., stand-replacing burn patch size and shape) have changed over this period of increased wildfire activity.

Stand-replacing fire was mapped reasonably well (71% overall accuracy). The mean proportion of stand-replacing burned area within wildfires increased from 25 to 30%, and the edge-to-area ratio of stand-replacing burn patches decreased from approximately 800 to 750 meters per hectare. Despite these trends, the mean patch size of stand-replacing fires did not change over time (12.5 hectares), nor did the mean amount of stand-replacing fire that was more than 150 meters from the edge of a stand-replacing

burn patch (380 hectares per fire). These results indicate that recent increases in fire activity are associated with an increase in the proportion of fires burning as stand-replacing fire but no change in the size and shape of patches of severe fire; rather heterogeneity of burn severity has remained relatively constant over the period 1984-2010. As fire-generated heterogeneity is integral to post-fire forest recovery processes and maintenance of forest ecosystem services, our results are encouraging for management of post-fire landscapes.

**Keywords:** fire severity, fire effects, climate change, RdNBR, Northern Rocky Mountains, remote sensing, landscape ecology

**Bio:** Brian J Harvey is a PhD candidate in the Ecosystem and Landscape Ecology Lab at the University of Wisconsin. His research is focused on changing disturbance regimes, disturbance interactions, and ecosystem resilience. Specifically, he is examining how two climate-driven disturbances (native bark beetles and wildfire) may lead to regional changes in western North American forest ecosystems. Using field data, remote sensing, and spatial analysis, he evaluates how different conifer species of the Northern Rockies might vary in their response to changes in spatial patterns of burn severity, and where transitions to non-forest may occur under future climate and disturbance regimes.

### 67. Wildland Fire Potential 2012: A Tool for Wildfire Risk Assessment and Fuels Prioritization

***Presenter:*** *Dillon, Greg, Spatial Fire Analyst, USDA Forest Service, Fire Modeling Institute*
***Additional Author(s):***
*Menakis, Jim, National Fire Ecologist, USDA Forest Service, Fire and Aviation Management*
*Fay, Frank, Applied Fire Ecologist, USDA Forest Service, Fire and Aviation Management*

Being able to spatially identify the relative degree of potential wildfire exposure across large landscapes is a frequently sought after goal for federal wildfire managers. To meet this need we developed a map that we call wildland fire potential (WFP) for the conterminous United States. The WFP map is a raster geospatial product that is intended to be used in analyses of wildfire risk or hazardous fuels prioritization at large landscapes (100s of square miles) up through regional or national scales. The WFP map builds upon, and integrates, estimates of burn probability (BP) and conditional probabilities of fire intensity levels (FILs) generated for the national interagency Fire Program Analysis system (FPA) using a simulation modeling system called the Large Fire Simulator (FSim). The specific objective of the 2012 WFP map was to depict the relative potential for wildfire that would be difficult for suppression resources to contain, based on past fire occurrence, 2008 fuels data from LANDFIRE, and 2012 estimates of wildfire likelihood and intensity from FSim. Using the FPA FSim products as inputs, as well as spatial data for vegetation and fuels characteristics from LANDFIRE and point locations of fire occurrence from FPA (ca. 1992 – 2010), we used a logical series of geospatial processing steps to produce an index of WFP for all of the conterminous United States at 270m resolution. Areas with higher WFP values represent fuels with a higher probability of experiencing high-intensity fire with torching, crowning, and other forms of extreme fire behavior under conducive weather conditions. We present the final WFP map in two forms: 1) continuous integer values, and 2) classified into five WFP classes of very low, low, moderate, high, and very high. On its own, WFP is not an explicit map of wildfire threat or risk, because no information on the effects of wildfire on specific values such as habitats, structures or infrastructure was incorporated in its development. Likewise, it is not a forecast or wildfire outlook for any particular season, as it does not include any information on current or forecasted weather or fuel moisture

conditions. It is instead intended for long-term strategic planning and fuels management, and we provide some examples of how it has been used to date.

**Bio:** Greg Dillon is a Spatial Fire Analyst with the Fire Modeling Institute (FMI) at the Missoula Fire Sciences Lab. He has a B.S. in Geography from James Madison University (Harrisonburg, VA), and an M.A. in Geography from the University of Wyoming. Greg joined FMI in April 2011 and uses his background in geography and ecology to help apply the latest advances in spatial analysis and fire science to land management questions.

### 68. Sources and Implications of Bias and Uncertainty in a Century of US Wildfire Activity Data

***Presenter:*** *Short, PhD, Karen, Research Ecologist, USDA Forest Service, Missoula Fire Sciences Laboratory*

The statistical analysis of wildfire activity is a critical component of national wildfire planning, operations, and research in the United States (US). Wildfire activity data have been collected in the US for over a century. Yet, to this day, no single, unified system of wildfire record-keeping exists. Data for analysis are generally harvested from archival summary reports from federal or interagency fire organizations; incident-level wildfire reporting systems of the federal, state, and local fire services; and, increasingly, remote-sensing programs. It is typical for research into wildfire activity patterns for all or part of the last century to require data from several of these sources and perhaps others. That work is complicated by the disunity of the various datasets and potentially compromised by inherent reporting biases, discussed here.

The availability of wildfire records with the information content and geospatial resolution generally sought for increasingly popular climatological analyses and the modeling of contemporary wildfire risk is limited to recent decades. We explain how the disunity and idiosyncrasies of US wildfire reporting have largely precluded true interagency, or all-lands, analyses of even recent wildfire activity and hamstrung some early risk modeling efforts. We then describe our efforts to acquire, standardize, error-check, compile, scrub, and evaluate the completeness of US federal, state, and local wildfire records from 1992-2012 for the national, interagency Fire Program Analysis (FPA) application. The resulting FPA Fire-Occurrence Database (FPA FOD) includes nearly 1.7 million records from the 21-year period, with values for at least the following core data elements: location at least as precise as a Public Land Survey System section (2.6-km^2 grid), discovery date, and final fire size. The FPA FOD is publicly available from the Research Data Archive of the US Department of Agriculture, Forest Service (doi:10.2737/RDS-2013-0009). While necessarily incomplete in some aspects, the database is intended to facilitate fairly high-resolution geospatial analysis of wildfire activity over the past two decades, based on available information from the authoritative systems of record. Formal non-federal wildfire reporting has been on the rise over the past several decades, and users of national datasets like the FPA FOD must beware of state and local reporting biases to avoid drawing spurious conclusions when analyzing the data. Apparent trends in the numbers and area burned by wildfires, for example, may be the result of multiple factors, including changes in climate, fuels, demographics, fire-management policies, and – as we underscore here – levels of reporting.

**Keywords:** Wildfires, data, statistical analysis, bias, uncertainty, USA

**Bio:** Karen Short is a Research Ecologist in the Fire, Fuel, and Smoke Science Program of the USDA Forest Service, Rocky Mountain Research Station, located at the Missoula Fire Sciences Laboratory. She received her PhD from the University of Montana. Karen has conducted fire-effects research in national parks of the southwestern US, has administered geospatial reference data on vegetation and fuels for the national LANDFIRE project, and currently remains focused on generating national geospatial datasets and analytical tools for wildland fire operations, research, and risk assessment/decision support applications.

**69. Emerging concepts in wildfire risk assessment and management**

***Presenter:*** *Scott, Joe, Wildfire management consultant, Pyrologix LLC*
***Additional Author(s):***
*Thompson, Matthew, Research Forester, USFS Rocky Mountain Research Station*

A quantitative framework for assessing wildfire risk across a landscape—expected net change in value of resources and assets exposed to wildfire—has been established for nearly a decade. Assessments made using that framework have been completed at a variety of spatial scales: counties, all or parts of National Forests, states, regions, and even the entire continental United States. The science of wildfire risk assessment and management is building on the basic framework to develop new analysis techniques that address specific fire management problems. This presentation reviews central concepts of the basic risk assessment framework and describes several emerging concepts and analysis techniques under development.

From the field of catastrophic risk modeling, used primarily in the insurance industry, we import the concept of a stochastic event set—thousands of possible future events with known probability of occurring. Fire modeling software already exists to generate stochastic wildfire event sets—the location, size, duration, final perimeter and intensity of possible future wildfires—on landscapes ranging from 1 million to 100 million acres.

Wildfire event sets form the basis for identifying a fireshed—the landscape area where fires can originate and eventually reach a point (or area) of concern, like a subdivision or critical wildlife habitat. A fireshed helps us focus fuel management on the portions of the landscape where an ignition is most likely to reach a susceptible resource or asset. Operationally, a fireshed can inform evacuation planning and development of management action points.

Spatially resolved fire effects models can be used to augment the information available for each event in the set. For example, a model of fire-caused sediment production can be used to assign total sediment production to each simulated wildfire. This augmented event set can then be used to produce an exceedance probability (EP) curve that relates the magnitude of a fire effect (sediment production, fire size, suppression cost, etc.) to the annual likelihood of meeting or exceeding that magnitude. The EP curve then permits the estimation of a "100-year wildfire event", a concept analogous to that used for floods.

By rearranging the central risk assessment components, the wildfire Risk Associated with an Ignition Location can be assessed (RAIL analysis). Such an analysis identifies locations where ignitions tend to have high consequences (due to spread potential and resource or asset vulnerability), suggesting where prevention and pre-suppression activities may have the greatest effect.

**Keywords:** 100-year fire, catastrophe modeling, stochastic event set, exceedance probability, fireshed

**Bio:** Joe is a wildfire management consultant based in Missoula, Montana. Over the past 18 years he has developed widely fuel characterization techniques and fire behavior modeling applications. Presently, Joe works with partners to apply wildfire modeling in quantitative risk assessments that address a variety of broad range of both government- and private-sector wildfire management problems.
Joe earned a B.S. in Forestry and Resource Management from the University of California at Berkeley and an M.S. in Forestry from the University of Montana. He is a Certified Forester™ as recognized by the Society of American Foresters.

**70. Multi-Dimensional Hazard Analysis of Post Wildland Fire Debris Flows**

***Presenter:*** *Haas, Jessica R., Spatial Analyst, US Forest Service Rocky Mountain Research Station*
***Additional Author(s):***
*Scott, Joe, Research Scientist, Pyrologix*
*Thompson, Matthew, Research Scientist, RMRS*

While wildland fire is necessary for the functioning of many ecosystems, human development in and around fire prone lands has created circumstances in which wildland fires are increasingly resulting in adverse impacts on human lives and highly valued resources. In addition to the direct effects of wildland fires, indirect effects can continue to impact human resources for years following a fire. One of the most hazardous and potentially destructive post wildland fire effects is the increased susceptibility of a burned area to debris flows. Post fire debris flows often occur with little warning and can endanger human lives as well as damage drinking water supplies and infrastructure.
Post fire debris flows occur in response to high intensity rainfall events on lands which have recently experienced a high severity fire. Much of the current research has focused on identifying areas most likely to produce a debris flow, after a high severity fire has already occurred, in order to prioritize areas for post-fire ground stabilization and rehabilitation. However, by identifying areas most likely to experience a future wildland fire, and subsequently experience a debris flow, mitigation measures can be taken to lower the intensity of a potential wildland fire, before it occurs. This form of pre-fire planning can substantially reduce the likelihood of adverse post-fire effects.

Although there is no way to know the location, extent, and severity of wildfire, or the subsequent rainfall intensity and duration before it happens; probabilities of fire and debris-flow occurrence for different locations can be estimated using simulation models. We present methods for integrating information on the historical frequency of various high intensity rainfall events, with wildland fire likelihood and subsequent debris flow likelihood to produce a combined hazard analysis of post fire debris flows.

We model thousands of potential wildland fire perimeters using the large fire simulator FSIM, for the Sandia Mountains in New Mexico. This information allows for a probabilistic distribution of the areal amount of a given watershed burned under high severity, a critical component of post-fire debris flow modeling. The wildland fire information in conjunction with the historical distribution of high intensity

rainfall events is in turn used to model debris flow volume and probability. The resulting multi-dimensional hazard distribution can be used to identify watersheds of highest concern for post-fire debris flow mitigation.

**Keywords:** hazardous fuels planning, debris flows, large wildland fires, water impacts

**Bio:** Jessica Haas is a spatial analysist for the National Fire Decision Support Center (NFDSC) economics research group. Her research is focused on using quantative spatial techniques and computer programming to develop wildland fire management decision support and risk assessment/mitigation tools and software. Current projects include incorporating future climate change weather scenarios into wildland fire simulation modelling to assess how wildland fire risk to highly valued resources may be changing in the future. She is also involved in projects related to Wildland Urban Interface mapping and community risk assessments.

**71. FireDST: Fire Impact and Risk Evaluation Decision Support Tool**

***Presenter:*** *Cechet, B.Sc., Dip.Met., Robert (Bob), PROFESSOR, UNIVERSITY OF NEW SOUTH WALES*
***Additional Author(s):***
*French, Ian, Senior Scientist,Environmental Geoscience Division, Geoscience Australia, Canberra, 2609 Australia*
*Sanabria, Augusto, Statistican, Environmental Geoscience Division, Geoscience Australia, Canberra, 2609 Australia*
*Yang, Tina, Senior GIS Officer, Environmental Geoscience Division, Geoscience Australia, Canberra, 2609 Australia*

The Council of Australian Governments in 2002 recognised that Australia needed to develop and use sophisticated fire modelling techniques as an aid in the prevention and mitigation of bushfires. This directive was further reinforced by the recommendations from the Victorian Bushfire Royal Commission in 2010 following the disastrous “Black Saturday” fires of 2009. In 2011, the Australian Bushfire Cooperative Research Centre initiated the FireDST (Fire Impact and Risk Decision Support Tool) research project. This project sought to examine all aspects of modelling extreme fires in Australia. One of the main outcomes was the development of a “proof-of-concept” computer simulation system that could predict the likely spread of a bushfire that has just ignited.

The FireDST “proof-of-concept” system links various databases and models, including the Bureau of Meteorology’s new “high resolution” ACCESS Numerical Weather Prediction system, the Phoenix RapidFire fire spread model and also the CSIRO building vulnerability assessment model, as well as infrastructure and demographic databases provided by Geoscience Australia. CSIRO’s smoke dispersion model is the last stage of the system, and it provides spatial information regarding smoke concentration and likely human impacts. The information is assembled into an integrated simulation framework through a geographical information system (GIS) interface. Census-derived social and economic information as well as extensive quantity surveying of asset values are also included
FireDST produces uncertainty simulations that are based on an understanding of the issues that may occur, for instance simulating multiple individual fires that have different ignition points and start times, vegetation and fuel characteristics, and variations in wind speed and direction. All the individual

simulations are amalgamated into a probabilistic view of the fire spread based on the estimated uncertainties.

This presentation provides an overview of the FireDST simulation “proof-of-concept” tool and walks through a sample probabilistic simulation constructed using the tool. The “proof-of-concept” system has demonstrated the successful generation of probabilistic fire spread as well as the impact associated with the probabilistic fire spread. Graphs and tables can be displayed showing the exposure across the probability shape (eg. those houses and people in the 75-80% probability area). The presentation describes the model in the context of its use in bushfire management, by providing an example event simulation that emulates the disastrous Kilmore Fire in Victoria on 2/7/2009 (173 lives lost and over 2000 homes destroyed).

**Keywords:** fire behaviour, fire management, Keywords: bushfire hazard and impact simulation

**Bio:** Bob is an Adjunct Professor with the University of New South Wales (Australian Defence Force Academy) and is the Project Leader of the Fire Impact & Risk Evaluation Decision Support Tool (FireDST) project (multi-agency, multi-disciplinary team over five sites numbering more than 25 people), which is the largest project within the Australian Bushfire Cooperative Research Centre. He has had a 30+ year research career focusing on climate hazards and risk associated with extreme events. Bob is a member of the executive for the Australian Meteorological and Oceanographic Society (AMOS) as well as for the Australasian Wind Engineering Society (AWES).

### 72. Evaluating Associations between National Fire Danger Rating System (NFDRS) Indices and Daily Wildland Fire Activity Characterized Using Time-series of Agency Incident Reports and Satellite Observations

***Presenter:*** *Freeborn, PhD, Patrick, Post-doctoral Scientist, South Dakota State University, Geographic Information Science Center of Excellence*
***Additional Author(s):***
*Cochrane, Mark, Professor, SDSU GIScCE*
*Jolly, Matt, Research Ecologist, USFS RMRS Fire Sciences Laboratory*

Fire and resource management decisions in the US are informed – in part – by historical relationships between fire weather and fire occurrence. Indices output from the National Fire Danger Rating System (NFDRS), such as the Energy Release Component (ERC), are traditionally associated with the number of new fires reported on a particular day and their corresponding final fire size. These associations are most appropriate for assessing the potential (over a large area) for a fire to ignite, spread, and become difficult to control, and are therefore most useful for fire prevention and pre-suppression planning. Such associations, however, do not provide any insight into the probability of occurrence, number, or potential growth of incidents beyond initial attack. This work addresses this gap and examines for the first time the ability of NFDRS indices to explain daily fire activity within an individual Predictive Service Area (PSA) located in North Central Idaho and the Bitterroot-Sapphire Mountains (NR05). Between 2003 and 2012, daily ERC values in the PSA were calculated based on a collection of seven Remote Automated Weather Stations (RAWS). The daily number of new and ongoing incidents managed by the United States Forest Service (USFS), and their daily fire growth, were derived from four data sources: (1) the United States Geological Survey USGS (USGS) compiled Federal Wildland Fire Occurrence Data, (2)

historical incident ICS-209 reports, (3) the Moderate Resolution Imaging Spectroradiometer (MODIS) Direct Broadcast (DB) Burned Area Product (MCD64A1), and the MODIS Active Fire Product (MCD14ML). Results indicate that for any given day, the probability and number of new and ongoing incidents managed by the USFS, their daily fire growth rate, and their energy release rate, as quantified using satellite measurements of Fire Radiative Power (FRP), consistently increased with an increase in ERC. As such, this work demonstrates the as-of-yet untapped capability of NFDRS indices to characterize the potential evolution of incidents beyond the first report date. Furthermore, the agreement of the associations developed herein, and our understanding of fire activity within the region, suggests that in the absence of agency reports, gridded fire danger indices (including those calculated using the NFDRS) are well poised to be associated with satellite-based burned area and active fire observations for continental-to-global scale analysis, evaluation, and interpretation.

**Keywords:** fire danger, ongoing incidents, daily fire growth rate, associations

**Bio:** Patrick is currently a post-doctoral fellow at South Dakota State University. He has a Master's in Forestry from the University of Montana, a PhD in Geography from King's College London. In the past, his research primarily focused on the thermal remote sensing of active fire characteristics, but more recently he has been comparing and contrasting fire regime parameters derived from different satellite-based active fire and burned area datasets. In this work, he leverages his experiences as a wildland firefighter and his understanding of Earth observation data to interpret the association between daily fire danger indices and daily fire activity.

### 73. Understanding the Roles of Vulnerability, Adaptive Capacity, and Mitigation Planning in Community Resilience to Wildland Fire

***Presenter:*** *Nielsen-Pincus, PhD, Max, Assistant Professor, Portland State University*
***Additional Author(s):***
*Paveglio, Travis, Assistant Professor, Department of Conservation Social Science, University of Idaho*
*Abrams, Jesse, Postdoctoral Research Associate, Institute for a Sustainable Environment, University of Oregon*
*Moseley, Cassandra, Senior Research Associate and Director, Institute for a Sustainable Environment, University of Oregon*
*Carroll, Matthew, Professor, Department of Natural Resource Sciences, Washington State University*

Wildland fire increasingly poses risks to many urban-interface communities. In response to these risks, many communities are attempting to become more resilient by organizing their collective capacities to better plan for, respond to, and recover from wildland fire. Community resilience for wildfire may depend on a range of factors that contribute to or reduce potential impact. For instance, discussion of resilience needs to take into account local vulnerability to wildfire, including biophysical exposure such as fuel loadings, expanding numbers of residents at risk, and resident demographics such as poverty or age that limit their ability to reduce risk. Resilience also needs to take into account adaptive capacity, or the collective and individual capacities that facilitate action to reduce wildfire risk and aid recovery. Adaptive capacity can include community or neighborhood initiatives for wildfire response, local knowledge and experience, or local initiatives to the procure resources to improve infrastructure and reduce risks. Both vulnerability and adaptive capacity intersect with hazard planning, including the

development of codes and standards that incentivize fire-conscious mitigation actions or the assessment of potential risk.

The relationship between these intersecting aspects of resilience is not well defined for wildfire. The goals of this study are to: (1) explain interactions among vulnerability, adaptive capacity, and natural hazard planning and mitigation efforts; and (2) identify how these factors collectively influence community resilience. To achieve these goals, we studied a panel of communities in the western U.S. that recently experienced large wildland fires. Our approach for studying influences on wildfire resilience was multi-faceted; specifically we: (1) collected local census data for 414 western counties to evaluate socioeconomic vulnerability using lessons from existing hazard literature; (2) reviewed 113 community wildfire protection plans to evaluate the content of hazard planning; (3) used insights from steps 1 and 2 to survey 128 county and community leaders about the factors that most influence local wildfire resilience; and (4) gathered data such as fire size and suppression costs for 514 large wildland fires to contextualize the types of hazards faced by local communities. In this presentation we explore how community wildfire planning interacts with local adaptive capacity in urban-interface communities, and examine whether adaptive capacity and planning help local communities overcome what would otherwise appear to be high levels of vulnerability. We draw conclusions from the quantitative data and use insights from interactions with fire managers and community stakeholders to interpret those conclusions.

**Keywords:** Wildfire; risk; adaptation; natural hazard planning; mixed methods; social science

**Bio:** Dr. Nielsen-Pincus is assistant professor in the Department of Environmental Science and Management at Portland State University. He teaches and researches the human dimensions of natural resource management. Dr. Nielsen-Pincus has studied the effects of large wildfires on local labor markets, the effects of wood products and biomass facility location on federal fuels management, and private landowner motivations for wildfire risk reduction. Dr. Nielsen-Pincus worked for five years as research faculty at the University of Oregon's Institute for a Sustainable Environment, and received his doctoral degree from the Department of Forest Resources at the University of Idaho.

### 74. The 'social' Issues of measuring Wildfire Awareness and Preparedness

***Presenter:*** *Wuerzer, PhD, Thomas, Assistant Professor, Boise State University*
***Additional Author(s):***
*Eric Lindquist, Ph.D., Director of Pulic Policy Research Center, Boise State University*

The damages caused by wildfires in 2012 and 2013 in many U.S. states such as the number of fires, burned acreages, and destroyed lives and property are devastating and a threat to the quality of life. It is evident that not just urban & regional planning needs rethinking of residential developments into fire prone zones but also that there is a high need for additional policy considerations while facing multiple social issues in decision making processes.

The presentation establishes a discussion of wildfire hazards and associated risks at the local level and escalates then up to a regional discussion in regard to wild fire mitigation and policy. The wildland urban interface (WUI) as a zone where urban/rural development meet fire prone vegetation/ fuels, holds high risks but is also receiving area of growth pressure in growing regions. In the case of Boise, and the Boise-Nampa metro region, the largest urbanized area in Idaho with 660,000 residents in Idaho (1.6 million residents), the WUI zones around Boise will potentially absorb developments (not counting infill) for estimated 400,000 new residents within the next 15 years. This creates a critical situation for Boise and close-by municipalities that have subdivisions in proximity to dry grasslands or neighborhoods in the Boise Foothills – subdivisions surrounded by wildlands and fronting hills/slopes that accelerate fires. In addition, under extreme climate situations the emergency management 'circle' of plan-prepare-respond-recover overlaps with related hazards and occurs causing multipliers and potential 'disaster chains' with shattering impacts to communities.

Our survey, conducted in select neighborhoods embedded by Boise's WUI, presents insights to homeowners' perception of wild fire risk, their awareness and preparedness. Besides traditional statistical analysis we will presents a novel approach to GIS and visualization of risk, awareness, and preparedness transferable to other communities located in the WUI. Presenting homeowners' attitudes on awareness and preparedness in such context adds to the knowledge of hazards planning while giving insights where planning and policy need adjustment to create better WUI-planning. Yet, it is unclear if planning in the WUI is a market issue, a policy problem, or the result of non-thoughtful planning and zoning due to growth pressures, or a combination of all.

We present a risk-perception-directional analysis that gives insights on how residents allocate risks in relation to their homes. As part of the findings, this study is exemplar for the issues social-based survey work can face in an uneasy environment for surveys.

**Keywords:** Risk perception, Data/Methods, GIS, Quality of Life Surveys

**Bio:** Thomas Wuerzer holds a Ph.D. in Regional Development Planning and is Assistant Professor in Boise State University's Department of Community and Regional Planning. His work and research are bridged by an in-depth background in Geographic Information Systems (GIS). Prior to Boise State University, he was the first Doctoral Fellow of the Cincinnati Area GIS consortium (CAGIS) and received national recognition for his software in emergency and infrastructure (asset) management. He is actively researching regional planning issues of wildfires within the Wildland Urban Interface with focus on wildfire and related hazards' impacts on natural and built environment, wildlife and human habitat.

**75. Modeling structure losses to wildfires across the conterminous United States**

***Presenter**: Alexandre, Patricia, Graduate Research Assistant, Department of Forest and Wildlife Ecology - University of Wisconsin - Madison*

***Additional Author(s):***
*Mockrin, Miranda, Research Scientist, Rocky Mountain Research Station - USDA Forest Service*
*Stewart, Susan, Staff Social Scientist, University of Wisconsin - Madison*
*Hammer, Roger, Associate Professor, School of Public Policy - Oregon State University*
*Keuler, Nick, Lecturer, Department of Statistics - University of Wisconsin - Madison*
*Clayton, Murray, Professor, Department of Statistics and Department of Plant Pathology, University of Wisconsin - Madison*
*Bar-Massada, Avi, Lecturer, University of Haifa - Faculty of Natural Sciences - Israel*
*Syphard, Alexandra, Senior Research Scientist, Conservation Biology Institute, CA*

*Radeloff, Volker, Associate Professor, Department of Forest and Wildlife Ecology - University of Wisconsin – Madison*

Wildfire in the Wildland Urban Interface (WUI) is a problem affecting people, property, and ecosystems nationally. Annually, fire suppression and property damage, including approximately 2,000 houses destroyed each year, costs billions of dollars. The rate of structure losses will potentially worsen because of ongoing housing growth into wildlands, as well as potential effects of climate change. Our goal was to identify the biophysical and spatial factors that contribute to structure loss throughout the United States. Vegetation, topography and climate are known to influence the composition and condition of fuels and thus the intensity, extent, and duration of fires. Topographic heterogeneity and the spatial pattern and arrangement of housing development have also been shown to play a role in the likelihood of property loss. We sought to determine how vegetation and location interact to influence structure loss, and whether vegetation is more important in some regions and location in others. We used Google Earth imagery to digitize exposed structures (within the fire perimeter) in all fires that occurred within the 48 contiguous states between the years 2000 and 2010. We used logistic regression with a genetic algorithm to select the best model and Bayesian model averaging to rank the variables. We assessed spatial autocorrelation in the models and adjusted for its presence. Our preliminary results show that terrain and vegetation explained the majority of structure loss; wildland vegetation plays an important role at the landscape level as it enables/carries the fire close to structures, but the spatial arrangement of structures determines propagation once fire reaches structure clusters. In addition, there is variability among ecoregions, so that factors exert different influence depending on where the fire occurs. Research can help to mediate the ongoing conflict between fire and people by guiding community adaptation to fire. Better understanding of the factors influencing structure loss could assist future planning for fire events, including the prioritization and consequent allocation of resources. Understanding the dynamics between vegetation, topography and spatial location of structures could direct placement of new structures to reduce the chance of loss to fire, and in established communities, could help prioritize where vegetation management should occur and what form it should take (e.g. a structure located in a high likelihood of potential loss may need a larger defensible space than one in a lower risk area).

**Keywords:** Wildland Urban Interface (WUI), Logistic regression, Modeling, Ecoregions, Structure loss, National Analysis

**Bio:** Since 2010: Forestry Ph.D. student, University of Wisconsin – Madison
2014: Awarded individual Doctoral Fellowship, Portuguese national funding agency for science, research and technology, January 2014.
2010: Awarded Fulbright.
2009: Master's Degree in Forestry (2008-2009), Technical University of Lisbon, Portugal
2007: B.S. Forestry, Technical University of Lisbon, Portugal
2004: Post Graduation Work, Planning and Management of Adventure Tourism, Escola Superior de Hotelaria do Estoril, Portugal

Research interests: Wildland Urban interface (WUI) systems, Housing loss to Wildfires, methodologies and procedures using remote sensing, satellite imagery, modeling techniques and GIS applications, develop programming skills with R and Python.

### *76. Novel Strategies for Overcoming Barriers to Fire Science Communication*

***Presenter:*** *Moritz, PhD, Max, UC Cooperative Extension Specialist, UC Berkeley, ESPM*
***Additional Author(s):***
*McLeod, Karen, Managing Director, COMPASS*
*Balch, Jennifer, Assistant Professor, Penn State Department of Geography*
*Turner, Monica, Professor, UW-Madison Department of Zoology*

Global wildfire dynamics are changing, with fires in many locations occurring at times and scales that may be atypical of the recent past. People are living in places they haven't before, changing the nature and extent of challenges at the wildland-urban interface. Drier conditions in the west are lengthening the fire season, with this year's season starting very early in both California and Oregon. Regime shifts and introduced species are leading to novel environments in which we do not yet fully understand the role of fire. Amidst all of these changes, the public and policymakers struggle with the tremendous price tag for fighting fires, the heavy toll of fire on communities, and many unanswered questions: How much should we be investing in fire suppression compared to hazard reduction, restoration, or mitigation of structure vulnerabilities? To what degree are large, high severity fires natural? How are fire regimes changing with climate change? In addition, misconceptions about fire abound: fire is almost universally seen as devastating; natural fire regimes are sometimes thought to be similar across different ecosystem types, implying common management strategies; if differences in fire regime are recognized, often they are over-simplified into a few basic types; and fuel treatments are often assumed to equate to restoration. In this talk, we will share insights from an April 2014 workshop that convened leading academic and agency scientists to tackle the myriad communication challenges for fire science and build bridges within this diverse and growing scientific community. Workshop participants explored some of the hard questions that the public and policymakers debate, with a focus on what makes these questions hard to address. In some cases, it's a lack of scientific consensus. In others, it's the challenges associated with communicating uncertainty or our inability to clarify inherent complexity. Understanding why these communication barriers exist helps inform solutions to overcoming them. We will present novel messages and strategies to more effectively address these hard questions and inject cutting-edge fire science into conversations about how we as a society manage flammable landscapes and adapt to changing fire regimes.

**Keywords:** science communication, fire ecology & management, climate change

**Bio:** Max Moritz is faculty in the Department of Environmental Science, Policy, & Management at U.C. Berkeley and the statewide Cooperative Extension Specialist in fire ecology and management for California. His group studies controls on fire regimes at various spatial and temporal scales, with the goal of understanding and communicating the natural role of fire in terrestrial ecosystems.

### 77. Picking up the Pace: the Realities of Landscape-level Fire Management

***Presenter:*** *Bailey, John, Associate Professor, Oregon State University*

Much of our current debate about fire suppression, fire risk and fuels management show a serious disconnect of scale. Spatial and temporal patterns of wildland fire are unprecedented in land managers' experience and orders of magnitude greater than proactive treatment rates. Fuel accumulations have

and continue to markedly outpace our treatment rates, as well, feeding these wildland fires. We are already behind in this game AND still losing ground. Given budget and workforce constraints, agencies allocate fuels/silvicultural prescriptions to a limited number of stands each year, and over relatively small areas. Additional constraints (e.g. "protection" of late-successional habitat) further complicate the allocation problem. It is unrealistic to assume that managers could truly account for all the issues and how they change in time and space; however, there are some basic patterns and realities for which we should all account in our land management. Four basic rules can form the foundation for picking up the pace of treatments: 1) wildland fire is a growing reality and cannot be excluded from ecosystems any more than humans or exotic species; 2) fire behavior is imminently predictable at the smallest scales but unpredictable at the largest – and we manage landscapes between these two extremes; 3) given a lack of predictability (and control), we must relax our expectations for suppression and conservatively build spatial resistance and resilience into landscapes that provide for a mix of early- and late-successional habitat; and 4) wildland fire will be a partner in that process one way or another. Therefore, instead of suppressing fire under moderate fire weather (when we can), we should aggressively extend its perimeter to scale-appropriate landscape boundaries, including previous burn scars that serve as fire lines. This approach requires the proactive identification and preparation of fireshed boundaries and an evolution in incident command decision making. It has risk, of course; however, that risk is reduced in each successive year that we are not lapped by fuel accumulation, and the inevitable risk of landscape-level fire under severe weather later that season or ensuing years is progressively reduced. The details of landscape-level fire management are important and site/personnel specific, but we should ponder how long we should dwell on those same details while we are being lapped.

**Keywords:** Wildland fire, Landscapes, Supression, Resilience

**Bio:** John received his BS and MF from Virginia Tech (as a native Virginian) and then worked for 6+ years with the EPA in Corvallis, Oregon on forest responses to climate. He returned to school for a Ph.D. (Silviculture) at Oregon State University, then joined the faculty at Northern Arizona University for nine years working in semi-arid silviculture, fuels treatment and restoration treatments, then returned to Oregon State in 2006 to continue work on fuels/fire management and ecosystem restoration in drier forest types, as well as resume research on multi-story management in wetter forest types. It is Oregon, after all.

**78. Fires Wild, Fires Tame, Fires Large: Assessing 50 Years of American Fire History**

***Presenter:*** *Pyne, Steve, Arizona State University*

In 1962 a revolution in fire philosophy, policy, and practice commenced in the U.S. It sought to replace fire control with fire management, fire's suppression with its restoration, and the hegemony of the U.S. Forest Service with a pluralism of regions and institutions. By 1978 most of that reformation – a revolution from the top – had achieved its goals in principle.

The 1980s, however, broke the process. It was a lost decade, culminating in the lost opportunity of the 1988 Yellowstone fires. When Revolution 2.0 rekindled around 1994, conditions – climatic, political, prevailing land uses - had turned against it along with the melancholy legacy of past fire practices. By now exurban sprawl constituted a veritable counterrevolution. By the time the National Fire Plan was

authorized, the occasion for dramatic change had passed. The agencies have been chasing fires ever since at greater difficulty and cost and with ever mounting studies. Megafire met metafire.
The contemporary scene began with a minor reformation in 2009 with new guidelines for policy, the FLAME Act, and the Collaborative Forest Landscape Restoration Program. The pyrogeography of the U.S. today shows four primary fire regions, three major hearths of fire culture that seem unable to cross their borders, and a complex and fragmented institutional setting that the National Cohesive Strategy is attempting to reconcile. The outlook will likely resemble an Obamacare for public wildlands.
In the western wildlands three strategies compete. One is regressive, one proactive, and one reactive. Suppression still flourishes, deferring fires at ever greater costs and unhinging other programs. The proactive campaign to get ahead of the fire problem continues to fall behind the rate of worsening conditions. Instead, a reactive default setting seems inclined to let wildfire, of any origin, do the burning that otherwise agencies have been unable to do. The implicit assertion is that it is too late to flank and pinch off the nation's fire problem, that the agencies will have to go indirect with big-box burnouts and point protection.

The institutional fire history of the country over the past century thus divides roughly in half. The first 50 years sought to remove fire under the spreading aegis of the U.S. Forest Service. The next 50 has sought to restore at least some fire under a pluralistic regime of private and public institutions. Neither wholly succeeded in its announced ambitions.

**Keywords:** fire history, institutions, politics, culture, policy

**Bio:** Steve Pyne is a historian in the School of Life Sciences, Arizona State University, and the author of over 20 books, most of them on fire. He is completing a two-part survey of the American fire scene with a narrative history and a complementary suite of region-based essays [firehistory.asu.edu]. The presentation will summarize the narrative half of this study.

**79. Spectroscopic Analysis of Seasonal Changes in Live Fuel Moisture Content and Dry Matter**

***Presenter:*** *Qi, Yi*
***Additional Author(s):***
*Philip E. Dennison*
*W. Matt Jolly*
*Rachael C. Kropp*

Live fuel moisture content (LFMC), the ratio of water massto dry mass contained in a live plant, isan important fuel propertyfor determining fire danger and for modeling fire behavior. Remote sensing estimation of LFMC often relies on an assumption of changing water and stable dry matter over time. In order to advance understanding of seasonal variation in LFMC and dry matter along with their spectral expressions, we collected field samples and spectroscopic data for two species, lodgepole pine (Pinus contorta Douglas ex Loudon) and big sagebrush (Artemisia tridentata Nutt).We compared new and old needles for lodgepole pine. All samples were measured using a visible/NIR/SWIR spectrometer, and coincident samples were processed to provide LFMC and biochemical constituentsof dry matter including structural and non-structural carbohydrates. New needles initially showed higher LFMC and a smaller proportion of dry matter, but differences between new and old needles converged as the new needles matured. New needle dry matter had strong temporal trends, and dry matter explained more

variation inLFMC than waterin both new and old needle. Sagebrush leaves exhibiteddecreasing trends in LFMC, butwater and dry mattercomparably contributed toLFMCseasonal variation. Spectral variation in response to changing dry matter is difficult to isolate from the spectral signatures of multiple biochemical constituents, including the dominant absorption features of water and pigments. Partial least square regression combined with imaging spectroscopic data may improve remote LFMC estimation, with the caveat that for some species (e.g. lodgepole pine), estimated LFMC may dominantly reflect phenological variability in dry matter rather than water content.Since new needles should have stronger spectral expression at the canopy scale, differing temporal trends in new and old lodgepole pine needles provides an additional complicating factor for remote monitoring of LFMC.

**Bio:** My research interests lie in remote sensing of vegetation, plant physiology and geospatial methodology, specifically retrieval of biophysical and biochemical properties of vegetation from multispectral and hyperspectral data, with application of fire hazard and natural resource management. My Ph.D. dissertation is about remote sensing estimation of live fuel moisture. I hold a Masters in Geography from Northern Illinois University and Bachelor in GIS from China University of Geosciences.

### 80. Landscape-Level Relationship of Fire Radiative Power and Energy to Surface Fuel Load

***Presenter:*** *Hudak, Andrew, Research Forester, USFS Rocky Mountain Research Station*

***Additional Author(s):***
*Matthew Dickinson*
*Robert Kremens*
*Benjamin Bright*
*Kevin Satterberg*
*Louise Loudermilk*
*Ben Hornsby*

The relationship between fire radiative energy (FRE) and biomass combusted is known from controlled experiments to be linear. Our objective was to estimate these variables empirically from multi-scale measurements and then compare them across five landscape-level prescribed burns conducted at Eglin Air Force Base in the Florida Panhandle in 2011 (n=2) and 2012 (n=3). The burn units ranged in size from 127-1147 ha. The three forested units had an open longleaf pine overstory with ~40% canopy cover, a patchy understory of mainly turkey oaks, and a discontinuous surface fuel layer composed of grasses, forbs, shrubs, and litter. The two non-forested units had a heterogeneous mix of grasses, forbs, shrubs, and turkey oak similar in structure and composition to the understory of the forested units. Clip plots were installed to sample fuel loads pre- and post-fire, from which unit-level estimates of combustion were derived. Surface fuels were mapped across the units from a multiple linear regression model predicting pre-fire surface fuels measured at the pre-fire clip plots (0-12 Mg/ha) from height and density metrics of surface fuel structure, derived from airborne discrete LiDAR returns collected immediately pre-fire. The best regression model (R2 of ~0.4) was based on the mean, mode, and standard deviation of LiDAR returns in the combustion zone 0-2 m above the ground. A single predictive model was applicable across both the forest and non-forest units. Estimates of FRE were mapped across the units by integrating estimates of fire radiative power (FRP) derived from long-wave infrared (LWIR) image time series collected at 3 second intervals from multiple overhead passes with the airborne WASP thermal imaging sensor. Estimates of radiant flux density calculated from WASP were validated with estimates of similar magnitude (1-10 W/m2) calculated from ground-based FLIR thermal imaging cameras. Mapping of FRE has great potential for remote estimation of pyrogenic biomass combustion and emissions but is challenged by spatial and temporal undersampling in the FRP record, as will be discussed, along with the utility and limitations of quantifying fuel loads and fuel consumption at the landscape scale. We conclude that the tree overstory does not preclude remote sensing of surface fuels in the understory with airborne LiDAR, or remotely sensed observations of radiant heat release as surface fuels burn. Unit-level estimates of FRE and surface fuels combusted relate logically but vary due to many factors. More landscape-level prescribed fire experiments are needed in other fuel conditions and ecosystems.

**Keywords:** Fire Radiative Power, Fire Radiative Energy, LiDAR, Surface fuels, WASP

**Bio:** Professional Experience:
2001-Present, Research Forester, Rocky Mountain Research Station, Moscow, ID
1999-2001, Research Ecologist, Pacific Northwest Research Station, Corvallis, OR
1990-1992, Secondary School Science Teacher, U.S. Peace Corps, Malawi
Education:
PhD, University of Colorado, 1999, Environmental, Population, and Organismic Biology
BS, University of Minnesota, 1990, Ecology, Evolution, and Behavior
AA, Itasca Community College, 1987, Liberal Arts
Research Interests:
Landscape-level characterization of terrestrial vegetation structure and function, fire and other disturbance ecology, forest and rangeland ecosystem management.

### 81. Long-term prescribed fire effects on litter and soil carbon in upland oak forests

***Presenter:*** *Hallgren, Stephen, Assoc. Prof., Oklahoma State University*

Prescribed fire is an important tool for restoring and maintaining upland oak forests. The beneficial effects for controlling invasive and exotic species, reducing fire hazard and maintaining biological diversity have been studied. Less well understood are effects on other ecosystem services. Litter, the fuel consumed in prescribed fire, is an important component of biogeochemical cycles, a reservoir of C, and protection against soil erosion. Even infrequent burning, one fire in ten years, can consume up to 30% of litter production and frequent burning every 2 years can consume 85% of litter production. Studies of litter decomposition and soil carbon in upland oak forests prescribed burned or left non-burned over a 20-year period showed effects were most likely only at the highest burn frequency, every two years. Evidence suggested long-term frequent prescribed burning could reduce litter decomposition rate through effects on litter quality but conflicting results lead to the more general conclusion that litter quality was the most important determiner of decomposition rate and litter quality could not be directly tied to burn frequency. Soil C to a depth of 20 cm was related to litter characteristic including C:N and lignin:N and these variables could not be linked to prescribed fire frequency. Results suggested frequent long-term prescribed burning up to every 2 years had only minor effects on soil C despite consuming a large proportion of litter production.

**Keywords:** litter decomposition, litter quality, ecosystem services

**Bio:** Steve Hallgren is a research scientist and teacher at Oklahoma State University concerned with effects of wildland fire on structure, composition and ecological function of forest vegetation.

**82. Airborne Laser Scanner-assisted estimation of prescribed fire fuel consumption**

***Presenter:*** *Skowronski, PhD, Nicholas, Research Forester, USDA Forest Service*
***Additional Author(s):***
*Simeoni, Albert, Professor, The University of Edinburgh*
*Clark, Kenneth, Research Forester, USDA Forest Service*
*Gallagher, Michael, PhD Student, Rutgers University*
*Kremens, Robert, Research Professor, Rochester Institute of Technology*
*Mell, William, Research Combustion Engineer, USDA Forest Service*
*Mueller, Eric, PhD Student, The University of Edinburgh*

Wildland fire managers are coming under increased scrutiny over the placement and prioritization of fuel reduction treatments. As such, quantitative methods are needed for evaluating the effectiveness of these treatments at the landscape scale. Fuel and loading can be highly variable even within individual stands making it difficult to produce estimates with reasonable uncertainties from field plot data. When coupled with fuel structure and loading estimated from ground plots, Light Detection and Ranging (LiDAR) datasets can provide wall to wall estimates of various fuel load metrics. In this study, we used a direct estimation approach to estimate the amount of fuel that was consumed in approximately 20 prescribed fires in the New Jersey Pinelands. We collected field estimated fuel structure and loading data (forest floor, shrubs, and canopy) before and after these fires. Additionally, we collected airborne laser scanning (ALS) data before and after the fire events. The ALS data was processed to classify returns into ground and non-ground and ALS variables (e.g. mean height, maximum height, etc.) were estimated for the continuous extent of each burn unit at 25 x 25 m horizontal resolution. The dependent ALS variables were linked spatially to the independent field-based estimates and all subset-models were developed to predict the fuel consumption from the ALS variables. These models were used to develop maps of fuel consumption for the extent of each burn unit. We then directly estimated mean fuel consumption and standard error for each of the burn units. Approximately 50% of this data has been collected with field work and ALS collections slated to be completed in the spring of 2014. The use of ALS may dramatically decrease the uncertainty associated with estimating fuels, consumption and emission rates.

**Keywords:** LiDAR, Fuels, Consuption, Fuel Reduction Effectiveness

**Bio:** Nick Skowronski is a Research Forester with the USDA Forest Service's Northern Research Station in Morgantown, WV. His work is focused on the characterization of three-dimensional forest structure, using remote sensing techniques, as it applies to forest productivity and forest disturbance. Nick is also interested in quantifying the effectiveness of landscape scale fire management activities and also developing techniques to perform large-scale fire risk assessment in WUI communities.

**83. Crown Fuel and Stem Biomass Models for the Major Conifer Species of the Interior Northwest USA**

***Presenter:*** *Affleck, David, Associate Professor of Biometrics, University of Montana, College of Forestry*
***Additional Author(s):***
*Seielstad, Carl, Associate Professor, University of Montana*

Management of coniferous forests in the northwestern USA is increasingly being shaped by wildfire hazard mitigation, ecological restoration, and carbon sequestration considerations. These concerns, as well as more traditional timber management planning, require credible models of tree biomass and of the distribution of biomass across tree components, including crown fuels components. To address this need, a major tree biomass sampling effort was initiated across public, private, and tribal forest lands in the interior northwest; previously collected biomass data from published studies were also compiled. The tree data set included over 550 trees from 7 conifer species spanning 2.5-86.5 cm in breast-height diameter and distributed over a range of forest habitat types, elevations, stand densities. Nonlinear allometric biomass equations were developed incorporating alternative tree-level covariates measured in standard inventory programs and were calibrated using seemingly unrelated regression techniques. Modeling efforts revealed strong branch-level allometric relationships between mass and branch cross-sectional area, and demonstrated the need to incorporate crown length metrics into equations to predict crown fuel components. These empirical results accord with allometric scaling theory and provide new regional crown fuels and stem biomass equations for the major conifers species of the interior northwest. Relative to other crown biomass equations used in the region, appreciable differences in predictions emerge for large diameter trees and trees with large crown ratios. Beyond the tree-level, differences in predicted fuel loadings are documented for a range of stand conditions. The new equations are linked to parallel efforts describing crown profile geometry and the vertical distribution of crown fuels.

**Keywords:** crown fuels; tree biomass; allometry

**Bio:** David Affleck has been on faculty in the Department of Forest Management at the University of Montana since 2006. His research interests center on sampling methods for natural resources and statistical modeling of ecological processes. He also serves as Director of the Inland Northwest Growth & Yield Cooperative.

**84. Quantifying ladder fuels: A new approach using LiDAR**

***Presenter:*** *Kramer, Anu, UC Berkeley*
***Additional Author(s):***
*Collins, Brandon, Research Forester, Pacific Southwest Research Station*
*Kelly, Maggi, Cooperative Extension Specialist and professor in Residence, UC Berkeley*
*Stephens, Scott, Professor of Fire Science, UC Berkeley*

This study investigated the relationship between LiDAR and ladder fuels across a 17,800 ha landscape in the northern Sierra Nevada. Ladder fuels are often targeted in hazardous fuel reduction treatments due to their tendency to propagate fire from the forest floor to tree crowns. Despite their importance, ladder fuels are difficult to quantify. One commonly used approach is to calculate canopy base height,

which can be done with tree list data from plots or with 2-D imagery, but there are many potential sources of error using this and other methods. LiDAR is an excellent candidate to attempt to better characterize ladder fuels, but has only been used to address this question peripherally and in only a few instances. In this work, after establishing that landscape fuel treatments reduced canopy and ladder fuels at our site, we test which LiDAR-derived metric best differentiates treated from untreated areas. The metric of percent cover between 2 and 4 m proved to be the variable with the most explanatory power to distinguish treated from untreated pixels across a range of spatial scales. When compared to plot-based measures of ladder fuel classes this metric was able to differentiate between high and low levels of ladder fuels. These findings point to several immediate applications for land managers and suggest numerous new avenues of study that could lead to possible improvements in the way that we model wildfire behavior across forested landscapes in the US.

**Keywords:** LiDAR; ladder fuel; Sierra Nevada; forest structure

**Bio:** Anu is a PhD student at UC Berkeley under Scott Stephens and Maggi Kelly. She is interested in utilizing LiDAR to better characterize forest fuels.

### 85. Recent Findings Relating to Firefighter Safety Zones

***Presenter:*** *Butler, Bret, US Forest Service Fire Sciences Laboratory*
***Additional Author(s):***
*Parsons, Russ, Research Ecologist, US Forest Service*
*Mell, William, Research Mechanical Engineer, US Forest Service*

Current safety zone guidelines for wildland firefighters are based on the assumption of flat ground, no wind, and radiative heating only. Recent measurements in grass, shrub and crown fires indicate that convective heating can be significant especially when wind or slope are present. Measurements and computer modeling supports this finding and suggests that convective energy transport should be considered when assessing safety zone effectiveness any time wind or slope is present. The results of the research are presented along with recommendations for modifications to current safety zone guides.

**Keywords:** Firefighter safety, safety zones

**Bio:** Bret has been a research mechanical engineer with the FIre Sciences Laboratory for 21 years. His research focus has been characterizing energy transport for in fires for application to fire modeling and firefighter safety. He enjoys spending time with family and friends.

### 86. Stress and Coping in Wildland Fire Dispatchers

***Presenter:*** *Palmer, Charles, Associate Professor, University of Montana*

Although well over a quarter million people in the United States are currently employed as dispatchers, scant research has been undertaken focusing upon this occupational population. This scarcity of empirical knowledge holds especially true for those functioning as wildland fire dispatchers. While ample anecdotal evidence suggests that wildland fire dispatchers must contend with varying levels of stress while performing their job duties, and have a variety of different methods of coping with these stressors, research to date has not attempted to identify what these specific stressors are or the coping strategies used. Eleven current wildland fire dispatchers were interviewed, and these interviews were later transcribed and analyzed through the qualitative research methodology known as phenomenology. Analysis revealed three broad areas of stressors for those interviewed: work/life balance, organizational issues, and lack of control. Four coping strategies also emerged: striving for work/life balance, physical activity, service to firefighters, and social support. Future research is recommended to further our understanding of workplace stressors for wildland fire dispatchers, and how they cope with them.

**Keywords:** dispatchers, stress, coping

**Bio:** Charlie Palmer has worked in and around wildland fire for the past 23 years, including a variety of resource types (Helitack, Engines, Handcrew, Smokejumper) and a multitude of agencies (BLM, U. S. Forest Service, U. S. Fish and Wildlife Service). He completed his Doctoral work in 2001 in Guidance and Counseling, with an emphasis in Sport and Performance Psychology. For the past ten years, Palmer has worked with Mission Centered Solutions, serving as an instructor for L-380 and L-381 Leadership courses. He is currently an Associate Professor in the Health and Human Performance Department at the University of Montana.

### 87. Spatial and Temporal Characterization of Large Airtanker Use

***Presenter:*** *Stonesifer, Crystal, Biological Scientist, U.S. Forest Service, Rocky Mountain Research Station, Human Dimensions*
***Additional Author(s):***
*Thompson, Matthew, Research Forester, Rocky Mtn. Research Station, US Forest Service*
*Calkin, David, Research Forester, Rocky Mtn. Research Station, US Forest Service*
*McHugh, Charles, Fire Spatial Analyst, Rocky Mtn. Research Station, US Forest Service*

The appropriate role of large airtankers (LATs) in federal fire suppression in the United States has been the source of much debate and discussion in recent years as the U.S. Forest Service (USFS) has faced impending decisions about how best to address an aging fleet of contracted aircraft. Questions of fleet efficiency are complicated by inadequacies in historical data on airtanker use. A need for improved data collection systems for LATs was a key recommendation to come from a 2013 U.S. Government Accountability Office (GAO) investigation into actions made by the USFS and the U.S. Department of Interior (DOI) regarding fleet modernization. Our research has also identified deficiencies in data collection regarding LAT use in federal fire suppression, particularly with respect to capturing the objectives and outcomes of individual retardant drops. Using spatially-explicit drop location data from 2010 and 2011 for the conterminous U.S., we linked retardant drops to fire occurrence and resource ordering records to identify whether LATs were used during initial attack (IA), and if so, whether or not the fire was contained at the IA phase. Our analysis showed that despite federal policy stating that the priority for use is on IA, 43% of drops from 2010 and 2011 occurred during extended attack (EA) operations. In addition, containment rates of fires associated with LAT use are low; 75% of all IA drops were on fires that escaped IA containment efforts. We expand on this by incorporating drop data from 2012. Further, in order to qualify where and when drops occur, we explicitly characterize the conditions of use for all drops, particularly with respect to terrain, fuels, time of day, weather, and proximity to identified values at risk and areas of restricted retardant use. Preliminary results suggest that

approximately 35% of drops occurred in late afternoon (1500 – 1800 hours) and over 30% of all drops intersect with timber fuel models from the LANDFIRE dataset. Here we will elaborate on these results and discuss the potential implications related to the use of LATs in fire management operations.

**Keywords:** large airtankers, large fire support, initial attack, extended attack

**Bio:** Ms. Stonesifer is a researcher with the US Forest Service Rocky Mountain Research Station in the Human Dimensions program in Missoula, Montana. Her research is generally linked to questions associated with wildfire economics and risk. Most recently, she has focused on characterizing aviation use in wildfire suppression, particularly with respect to large airtankers.

**88. Safety Zones and Convective Heat: Numerical Simulation of Potential Burn Injury from Heat Sources Influenced by Slope and Winds**

***Presenter:*** *Parsons, PhD, Russ, Research Ecologist, USDA Forest Service, RMRS Fire Sciences Lab*
***Additional Author(s):***
*Butler, Bret, PhD, Research Mechanical Engineer, USDA Forest Service, RMRS Fire Sciences Lab*
*Mell, William, PhD, Research Combustion Engineer, PNW Research Station*

Although slope and winds are common factors in most wildland fires, current guidelines for safety zone dimensions assume flat ground and do not consider wind speed as a factor. Similarly, while convective heat transfer is an essential part of fire behavior and is often highly significant to firefighter safety, it has not been considered in past work establishing safety zone criteria. In recent years, 3D, dynamic, physics-based dynamic fire models have been developed which can help us to understand fire behavior and firefighter safety. Here, we used a 3D dynamic fire model, WFDS, to explore different factors influencing potential burn injuries that could arise from both radiative and convective heat transfer over a range of heat sources, slopes and wind speeds. As a simple, first stab at the problem, we considered a fixed (non-moving) heat source on an inclined plane. Above this heat source, at regular intervals along the slope, synthetic "sensors" tracked wind velocities, temperature, radiative and total heat fluxes, facilitating analysis of potential burn injury with increasing distance from the heat source, analogous to the radius of a safety zone. Our primary finding was that convective heat could result in burn injuries at distances several times what would result from radiation alone. We also found that, while all factors were important, the nature of the heat source (reaction intensity, flaming zone depth and residence time) had more pronounced effects on potential burn injury than slope or wind speed. Both of these findings have significant implications for how we think about firefighter safety, both in terms of how big safety zones might need to be to protect firefighters from convective heat, and in terms of characterizing the fuel as a heat source. This is a new arena of research investigation, and our work is just an early step; more work is needed to fully understand the implications of convective heat for firefighter safety and decision support.

**Keywords:** safety zones, physics-based fire model, firefighter safety

**Bio:** Russ is a Research Ecologist with the Fire, Fuels and Smoke research program at the USFS RMRS Fire Sciences Laboratory in Missoula, MT. Russ received his B.S. in Forestry from U.C. Berkeley, in 1992, his M.S. in Forestry from the U. Idaho in 1999, and his Ph.D. in Forestry from the U.Montana in 2007. Russ has worked in fire and resource management with several agencies. Russ started working at the Fire Lab in 2000 as a remote sensing and GIS specialist. His current research is oriented towards the development of new advanced systems for modeling fuels and fire behavior.

**89. Wildland Firefighter Smoke Exposure**

***Presenter:*** *Broyles, George, Fire & Fuels Project Leader, USFS and Domitrovich, Joe, Ph.D, Exercise Physiologist, USFS*

Wildland firefighters work in a dynamic environment and are exposed to a variety of hazards. One of the most common, but often overlooked, hazards is exposure to potentially harmful levels of contaminants in wildland smoke. This may also be one of the least understood risks of wildland firefighting (Reisen et al., 2009). With the increase in large scale fires across the Western United States and internationally, more wildland firefighters and support personnel are being exposed to wildland fire smoke at undocumented levels. The USFS under took a four year project to quantify exposure for wildland firefighters across the United States. Data was collected on wildland and prescribed fires in 17 states representing 11 of the 13 NFDRS fuel models. Exposure to carbon monoxide, respirable particulate matter (PM4) and crystalline silica (SiO2) were measured in the breathing zone of firefighters. Measurements were also taken at incident base camps.

Wildland firefighters are subject to exposure from a variety of inhalation irritants. Health effects include short-term conditions such as headaches, fatigue, nausea, and respiratory distress while long-term health effects may include an increased risk of cardio-vascular disease.

Direct observation of firefighters was done in order to determine which variables are related to high exposure so that firefighters and fire managers can be better prepared to reduce these exposures. During the four-year study, 7,517 hours of CO measurements on firefighters and 1,554 hours of CO measurements at ICPs and spike camps were taken.

Based on the findings there has been no appreciable reduction in firefighter exposure and in some instances unsafe exposures are more frequent and severe than previous research had found. Exposure to wildland smoke has direct consequences on the ability of firefighters to remain safe by compromising their ability to think clearly and function at their highest mental and physical level. Exposure to the harmful constituents in wildland smoke must be addressed effectively in order to assure risk management decisions are sound.

Preliminary findings and ongoing exposure efforts will be presented.

Data from this project is being utilized for JFSP Project Announcement No. FA-FON0013-0001, task statement 2; Health impairment from exposure to fire smoke: Relationships among the National Ambient Air Quality Standards (NAAQS) and industrial health guidelines. The status of this project will also be presented.

**Keywords:** Firefighter health, firefighter safety, risk management, carbon monoxide, respirable particulate matter

**Bio:** George Broyles is a Fire and Fuels Project Leader for the USFS National Technology and Development Program. He has worked for the USFS for 25 years in timber management and fire management. He completed his Masters in Natural Resources at the University of Utah, Logan and his Bachelors in Sociology and Political Science at Black Hills State University, Spearfish, South Dakota. His recent projects in support of wildland firefighter safety include the wildland firefighter smoke exposure and the hydrogen sulfide monitoring projects. He is a member of the NWCG Risk Management Smoke Exposure Task Group.

**90. Engine Safety Zone Emergency Device, a Last Resource Protocol**

***Presenter:*** *Duce Aragüés, José luis, Training Specialist, FOREX S.L.*
***Additional Author(s):***
*Linari, Federico, FOREX Fire Training Company General Manager, FOREX S.L.*
*Fernández, Manuel, Structural Engine Crew Boss, Córdoba Province Fire Agency (Spain).*
*Abad, Fernando, Fire-Fighter, Córdoba Province Fire Agency (Spain)*
*Fernández, Carmelo, Emergency Crew Member, GREA-Andalucía (Spain)*
*Jiménez, Jesús, Environmental Consultant, Jiménez Consulting.*

Fire perspective as a natural element in our Mediterranean ecosystem has turned into a unique negative destructive threat to people and structures, mainly in the Wildland and Agricultural Urban Interfaces in general and even in the rural areas in particular.

Human beings are behind the 95% of the causes and motivations of this problem in Spain, and urge to administrations, agencies and individual civilians to do a big effort to prevent and preserve our woods and ecosystems and safety.

According to statistics , 209.855 hectares were burnt in wildfires in 2012, the worst year in the last four decades. But the most impressive negative aspect is the repeated number of victims: 10 fatalities, more than 30.000 evacuated people in that same year.

Instead of decreasing, there is a constant (or even growing) number of people affected by wildfires consequences. According to the conclusions released in the 6th Forestry National Congress , from 1980 to 2010, 245 people died in incidents related to wildfire, of whom, 187 belonged to different fire-fighting resources. 126 of them died in entrapment incidents, the 50.8 % of all. During this period, we had an average of 7.9 casualties, 6 of them professionals working on the fire-line.
With these records, any safety protocol, mental, technical or physical training or tool or material related to safety, is never enough.

An interdisciplinary team of 6 people, coming from the wildfire suppression world with different backgrounds, conscious of this reality, has come together to the commitment of developing a last resource protocol and device, 'designed to protect people, engines and structures in emergency situations, as a result of the hazards and risks of the wild-land urban and agricultural interfaces' (as it says in the patent text of the tool) and wildfires in general.

The process of thinking, conceiving and testing, the planning and working together as a team sharing knowledge and experiences, the methodology in the investigation, with the sole, main and final purpose of safety and protection of lives, has made the 'journey' of creating this device, the best growing process both personal and professionally.

The main intent of our presentation will be showing that process, those conclusions and the final product through different ways, with the main focus on safety.

**Keywords:** Safety Zone Devices Engines

**Bio:** Born in Zaragoza (Spain) in 1973, he grew up as a professional in the supression world. After more than 20 years he has developed his career as a hand, engine and helicopter crew member. He is a Crew Boss in one of the BRIF elite helitack crews of the Ministry of Enviroment, and a Burn Boss in the North of Spain.
He has been training people and leading exchange programs in the States and Spain. He is the Latinamerican projects manager of Wildland Restoration International. Recently published 'Incendios de Interfaz. Manual de Actuación', a practical manual about interface.

**91. Historical Pattern of Large Wildfires and Other Forest Disturbances on the Island of Newfoundland**

***Presenter:*** *Arsenault, André, Forest Ecologist, Canadian Forest Service, Natural Resources Canada*

The forests of Newfoundland are interesting because they represent a unique type of boreal ecosystem at the edge of North America, on a large Island subject to exceptional oceanic and continental influences. These, combined with sharp environmental gradients have a very strong control on disturbances and vegetation. We have examined historical records of wildfire, insect outbreaks, and windthrow to provide a comprehensive overview of how the natural disturbance regime has changed through time in Newfoundland and make comparisons with its mainland counterpart. Historical wildfire records from various sources were examined for a period extending from 1619 to 2013. Large wildfires were mostly restricted to the Central forest and Maritime Barren ecoregions and rare on the rest of the Island. Although the occurrence of large fires is not as common in Newfoundland compared to continental boreal forests, the size of the largest fires are impressive, exceeding ½ million hectares. Anthropogenic ignitions (railway, forest industry, escape burns, and others) have been dominant in the last 50 years. Since the 1980's, the number of years with large fires have been significantly reduced most likely as a result of losing the railway and aggressive initial attack with aviation support. The most frequent and extensive disturbance is associated with spruce budworm outbreaks whose footprints extends to most of the forested areas of the Island with the exception of high elevation forests where the oldest balsam fir in the world can be found. Less extensive but locally important include the hemlock looper outbreaks which are generally more severe and more frequent than spruce budworm outbreaks. Windthrow is localized to the most exposed areas along the coastline, and appear to be most important in the Avalon forest ecoregion. A long history of forest harvesting, effective fire suppression, an overabundant moose population, and the introduction of the white pine blister rusts has the potential to radically change the forest structure and composition of Newfoundland. We examine management implications of this information, and illustrate how uncertainties about natural disturbances in Newfoundland are being addressed by new research initiatives.

**Keywords:** Large fires, insect outbreaks, Newfoundland, windthrow, spruce budworm, hemlock looper

**Bio:** André is a forest ecologist with the Canadian Forest Service, in Corner Brook Newfoundland and Labrador. His current research program focuses on the effects of natural and anthropogenic disturbances on biological diversity, forest dynamics, and ecosystem services along key ecological gradients He did a M.Sc. on sugar maple forest decline at UQAM, and a Ph.D. on the dynamics of old-growth coastal temperate rainforests in British Columbia at UBC. André worked as a plant ecologist with the BC Forest Service in Kamloops between 1995 and 2010 where he studied the ecology and management of a variety of forest types.

**92. Estimating Historical Annual Wildland Fire Burning Rates For the Contiguous United States Using LANDFIRE Data**

***Presenter:*** *McHugh, Charles, Spatial Fire Analyst, USFS, RMRS, Fire Sciences Laboratory*
***Additional Author(s):***
*Finney, Mark A., Ph.D., Research Forester, USFS, RMRS, Fire Sciences Laboratory*

The annual burning rate (acres per year) for pre-settlement fire regimes in the contiguous United States is important baseline information informing both ecological and practical management objectives. Recent studies observed that current rates of burning are far below those experienced prior to Euro-American settlement. For example, Leenhouts (1998) estimated that if historic fire regimes were restored to contemporary lands for the contiguous United States, excluding agricultural and developed areas; that between 44.5 – 106.3 million acres would need to burn annually. This means that on average approximately 2.3 - 5.5% of the total available area in the contiguous United States burning in any given year. Our objective was to investigate the applicability of LANDFIRE data sets to estimate the historical annual burn area for the contiguous United States if historical mean fire return intervals were restored to contemporary vegetation types. This analysis used LANDFIRE derived Existing Vegetation Type (EVT) to determine and exclude agricultural and developed areas and the Mean Historical Fire Return Interval (MFRI) data to calculate historical annual burn area. Our analysis suggests an historical annual area burned for the United States to be in the range of 73.6 to 219.8 million acres per year which is approximately 5.8% - 17.2% of the total available area in the contiguous United States. Using contemporary information, the amount burned by wildfire in any given year for the period 1990-2011 for the same area has never exceeded 1%. The current average area burned by wildfire per year for the contiguous United States is 16.7-49.9 times less than the estimated historical range of area burned per year suggested from this analysis. The analysis also suggests for the western United States an historical average annual area burned of 16.9-24.0 million acres per year, equating to approximately 2.2%-3.2% of the total available area. Contemporary average area burned by wildfire per year for the eleven western United States (1990-2011) is 5.8-8.3 times less than the estimated historical annual area burned from this analysis. The methodologies and results presented here hold promise for estimating historical annual wildland fire burning rates by offering a consistent and repeatable methodology using an available nationally derived dataset. To the best of our knowledge this is the first attempt using LANDFIRE data to investigate this question.

**Keywords:** Historical Fire Return Interval, Fire Regime, Fire Rotation, Burned Area

**Bio:** Charles (Chuck) W. McHugh has been a Fire Spatial Analyst for the Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, since June 2002. His current research involves spatial data analysis, large air tanker use and effectiveness, geospatial fire modeling, historical burn probability analysis, and wildfire/fuel treatment interaction and effectiveness. He provides technical support to the National Fire Applications Helpdesk for FARSITE, FlamMap, and FireFamilyPlus and has developed, coordinated, and taught local and national level workshops in the use of geospatial fire decision support systems, such as, FARSITE, FlamMap, and FSPro within the Wildland Fire Decision Support System (WFDSS).

### 93. Pre-settlement vs. modern fire regimes of the Sierra Nevada region

***Presenter:*** *Miller, Jay, USDA Forest Service, Pacific Southwest Region*
***Additional Author(s):***
*Safford, Hugh, Regional Ecologist, USDA Forest Service, Pacific Southwest Region*

Land use practices and fire suppression, particularly over the last century, have changed forest structure and impacted ecosystem function of some western US forests. Forests that historically experienced frequent fire are the most impacted. Recent and projected increases in fire activity underscore the need for altering forest structures to be more resilient to fire, and perhaps to projected changes in climate. Managers have focused on restoring, or mimicking historic disturbance processes (fire). Objectives for restoration for different forest types remain somewhat uncertain, especially with the recent emphasis on early seral at the expense of discounting late seral forests. We compare pre-settlement and modern fire regime attributes for forests of the Sierra Nevada region of eastern California. For lower elevation yellow pine and mixed conifer forests, the area burned at high severity (stand replacement) over the past few decades (1984-2009) is within the range of estimates for pre-settlement forests. However, there is a deficit of surface and mixed severity fire that historically served to maintain late seral forest structures. Significant extents of these forests could not have been in late seral condition if the modern proportion of high severity was typical during pre-settlement times. Proportion of high severity has been closer to historic rates in Yosemite NP, where there has been more extensive use of prescribed fire and a longer history of using natural ignitions for resource benefits. Data from eight published and two unpublished studies indicate that the pre-settlement fire size of fires > 10 ha averaged less than 300 ha, while fire perimeters from 1987-2011 indicate a mean fire size of 1400 ha. Fires and fire effects over the last 25 yrs do not appear to be typical of the presettlement fire regime of Sierra Nevada forests. Mechanical treatments, although useful in some locations, will not be the restoration answer in a majority of Sierra Nevada forests due to access restrictions. Restoration goals should strive to increase the amount of area burned at low and moderate severity through increased usage of prescribed fire and natural ignitions when weather conditions and social restrictions are favorable.

**Bio:** Mr. Miller is responsible for analyzing region-wide fire severity data to characterize/monitor current fire regimes and fire severity patterns. He was a member of the Monitoring Trends in Burn Severity (MTBS) team and he was a principal developer of the Rapid Assessment of Vegetation Condition (RAVG) program which is intended to support post-wildfire reforestation planning on National Forest lands. Mr. Miller has coauthored peer-reviewed journal articles on fire effects mapping and analysis of landscape level fire patterns. Mr. Miller holds Master degrees in Mathematics and Geography and is a certified Sr. Wildland Fire Ecologist, A.F.E.

**94. Changing Fire Regimes of the Great Sandy Region, South East Queensland**

***Presenter:*** *Stewart, Philip, PhD Candidate, School of Geography, Planning and Environmental Management, University of Queensland*
***Additional Author(s):***
*Moss, Patrick, Senior Lecturer, Dr. 1School of Geography, Planning and Environmental Management, University of Queensland.*

The focus of the study is to identify past, present and future changes in fire regimes on Fraser Island and the impacts of these changes on vegetation population dynamics including changes in temperature and precipitation regimes spatially and temporally. Fire is an important driver in the development of ecosystem evolution, composition, structure and distribution. With carbon dating records of charcoal dating back 40 thousand years ago, changes in vegetation composition, distribution and abundance in conjunction with changes in precipitation and temperature regimes may be identified. Fires have modified the islands ecosystems creating fire dependency and creating fire disturbance-adapted ecosystems. It is suggested that due to the importance of fire as an ecosystem modifier, plants developed traits to survive fire, such as resprouting post-fire and serotiny of cones and fruit. However such traits are not necessarily only developed through fire as a process of natural selection, other factors may play a role in such trait development within plants. Paleo-records and modern observations show a definitive link between fire and climate (temperature and precipitation), with an increase in fire with increasing temperatures. This has serious implications as in a warmer world there will be an increase in wildfire risk. Of importance is the understanding of the interactions between multiple drivers of fire regimes from the past and present. This is critical for developing fire regime management protocols for Fraser Island and the Great Sandy Region in the future.

**Keywords:** Fire regime, vegetation dynamics, evolution, fire dependency, wildfires, paleofire.

**Bio:** Philip holds postgraduate degrees in science and has worked in nature conservation and national park management for over 27 years in Namibia, South Africa and Australia. He has lectured in wildfire behaviour, fire ecology and other environmental science modules at Charles Darwin University for a number of years. Philip is currently undertaking a PhD at the University of Queensland on changing fire regimes of Fraser Island in south east Queensland's Great Sandy Region. The research focuses on past, present and possible future fire regimes for the region with temperature and precipitation as key drivers of change.

**95. Using Historic Photographs to Model Changes in Burn Probability of the Landscape Since European Settlement**

***Presenter:*** *Stockdale, PhD Candidate, Chris, , University of Alberta*
***Additional Author(s):***
*Macdonald, Ellen, Professor, University of Alberta*
*Flannigan, Mike, Professor, University of Alberta*
*Higgs, Eric, Professor, University of Victoria*

Across western North America, grasslands and open canopy forests have been lost to encroachment and densification of forests as a result of fire exclusion policies. These changes are believed to have

increased the susceptibility of forests to wildfire, and many management agencies are actively promoting wildfire management plans (prescribed fire, limited response, etc) to restore elements of a more historical landscape due to a belief that it is less “dangerous”. Is the current landscape is at greater fire risk than the historical landscape, and if so, what evidence do we have of this?
The Mountain Legacy Project is the world’s largest land-based oblique repeat photograph collection (1890-2010), and capture the landscape at the time of European settlement. Previous studies have been limited to qualitative description, or detailed analysis of only small areas (10’s of km2). Digital monoplotting is a new method to extract vector data from oblique landscape photographs for accurate spatial analysis. Focusing on the Beaver Mines-West Castle region of southern Alberta, the objective of this study was to measure how much the fuel complex has changed, and how this altered fuel complex affects the burn probability, rate of spread and headfire intensity. Burn probability is defined by the number of times a given unit (cell) on the landscape will burn under fixed conditions.
Initial results reveal that between 1900-2010, grass and deciduous fuels have declined in abundance, and coniferous fuels have largely replaced them. This change is most apparent on south and west facing aspects. Early Burn P-3 modelling runs reveal significant changes in fire behavior over this time period (burn probability, head fire intensity, rate of spread). Alberta Environment and Sustainable Resource Development has numerous prescribed and wildfire management plans, forest harvesting plans, and fuel treatment plans for the region. These results will provide management with quantitative measures and targets that they can use for managing vegetation to mitigate fire risk on a landscape scale. By fully exploring the potential of these photos using innovative techniques, we may be opening up an entirely new area of decision-support for land managers.

This presentation will describe a) the technique of digital monoplotting, b) the vegetation structure changes on the landscape and c) early model runs showing changes in fire behavior.

**Keywords:** historic change, burn probability, ecological restoration, digital monoplotting, oblique photo analysis

**Bio:** Chris received his MSc from Oregon State University in 2000, and then spent 4 years working for the Canadian Forest Service as a Forest Health Officer studying the relationship between fire and the current Mountain Pine Beetle epidemic. He then moved on to work as the Prescribed Fire coordinator for 3 years with the Province of Alberta before returning to school to earn his PhD.

### 96. Hydrologic implications of ground fires in low-relief landscapes

***Presenter:*** *Watts, PhD, Adam, Assistant Research Professor, Desert Research Institute*
***Additional Author(s):***
*Kaplan, David, Assistant Professor, University of Florida*
*McLaughlin, Daniel, Assistant Research Professor, University of Florida*
*Schmidt, Casey, Assistant Research Professor, Desert Research Institute*

Smoldering ground fires in organic-rich soils are understood to have negative effects: air quality and motorist safety, as well as broad-scale implications resulting from their release of large quantities of stored carbon. While negative aspects of smoldering fires are well established and widely acknowledged, ecological implications of their occurrence are relatively unexplored. Smoldering fires in organic soils may increase local hydroperiods and wetland storage, conferring benefits to wildlife. Short-term increases in productivity due to nutrient availability from ash may occur in or adjacent to areas affected by ground fires. Short-term negative feedbacks to fire occurrence are likely to occur locally, due to increased hydroperiods; however, adjacent uplands may experience hydrologic changes as well, including factors which may affect fire risk distally to areas of organic soil burned by smoldering ground fires. To explore hydrologic implications of soil-consuming ground fires, we developed a model based on a low-relief region in southern Florida, U.S.A., characterized by seasonal hydrologic fluctuations and areas of organic soil distributed across a landscape that experiences frequent fire. Parameterizing the model with local soil and hydrologic properties, as well as observed effects of fire in the region's organic soils, the model predicts changes to wetland depths, bathymetry, and storage competence; depending on fire severity (i.e., area and depth of burn) and management objectives, the resulting changes may be ecologically significant. These findings imply that both soil-consuming ground fires as well as their prevention each have implications that should be considered in the context of local ecohydrologic considerations.

**Keywords:** smoldering, hydrology, peat fire, organic soil

**Bio:** Adam Watts is an assistant research professor of fire ecology at the Desert Research Institute. His interests include fire ecology of wetlands, smoldering combustion, climate impact of emissions, and unmanned aircraft.

### 97. The effect of the degree of grass curing on the behaviour of grassland fires – an experimental study

***Presenter:*** *Cruz, Miguel, CSIRO Ecosystem Sciences, Australia*
***Additional Author(s):***
*Bessel, Rachel, CSIRO Ecosystem Sciences, Australia*
*Gould, Jim, CSIRO Ecosystem Sciences, Australia*
*Hurley, Richard, CSIRO Ecosystem Sciences, Australia*
*Kidnie, Susan, CFA, Fire and Emergency Management, Australia*
*Koul, Vijay, CSIRO Ecosystem Sciences, Australia*
*Nichols, David, CFA, Fire and Emergency Management, Australia*
*Alen Slijepcevic, CFA, Fire and Emergency Management, Australia*
*Ingrid Welles, Wageningen University and Research Center, The Netherlands*
*Martin Wyschka, Eberswalde University for Sustainable Development, Germany*

Key to understanding fire propagation in grassland fuels is to know their annual growing cycle and the availability of biomass to be consumed by a fire. Curing is the progressive senescence and drying out of grass after flowering (annuals) or in response to drought (perennials) and is the key process transferring biomass from the live to the dead fuel component. Despite the relevance of fires in grasslands and savannah ecosystems in Australia and throughout the world, our understanding of (1) grass senescence effect on overall fuel moisture content and fuel availability, and (2) the degree of grass curing in fire behaviour, is still lacking.

To investigate the effect of the curing process on grassland fire behaviour an experimental field study was conducted at two distinct locations in Victoria, Australia. Experimental burn plots size were 32 x 32 m. Simultaneous burns were conducted with one plot being fully cured (100%; control) and another

being partially cured (treatment). Detailed measurements of fuel bed structure, weather variables (3D wind speed, air temperature, relative humidity and solar radiation) and fire behaviour (rate of spread, flame length, residence time and time-temperature profiles) were recorded on 52 experimental fires. The range of curing in the partially cured plots varied between approximately 35% and 90%. The range of other fire environment parameters were: 2-m wind speed: 5.4 - 20.5 km/h; ambient air temperature: 16-33 C; relative humidity: 14-40 %; Fire spread rates varied between 3.6 and 72 m/min.
Preliminary analysis highlights include the observation of sustained fire spread with curing levels between 30-40% and the importance of the dead fuel component from the previous year growth to sustain propagation at these marginal conditions. The data collected is being used to reanalyze functional relationships currently used to express the effect of curing and live fuel moisture on the spread of grassland fires.

**Bio:** Miguel Cruz is a research scientist with the CSIRO Bushfire Dynamics and Applications Group.

**98. Modeling the spreading of large-scale wildland fires**

***Presenter:*** *Drissi, Mohamed, Corsica University*

The objective of the present study is twofold. First, the last developments and validation results of a hybrid model designed to simulate fire patterns in heterogeneous landscapes are presented. The model combines the features of a stochastic small-world network model with those of a deterministic semi-physical model of the interaction between burning and non-burning cells that strongly depends on local conditions of wind, topography, and vegetation. Radiation and convection from the flaming 13 zone, and radiative heat loss to the ambient are considered in the preheating process of unburned cells.
The model is applied to an Australian grassland fire experiment as well as to a real fire that took place in Favone in Corsica. Predictions compare favorably to experiments in terms of rate of spread, area and shape of the burn. Second, the sensitivity of model outcomes (here the rate of spread) to six input parameters is studied using a two-level full factorial design.

**Keywords:** wildfire, network model, radiation, convection, sensitivity analysis, validation, prescribed burning.

**Bio:** The presenter is recently teaching and making his reserach on the topic of wildland fire in the university of Corsica "Pasquale Paoli". He made his PhD research at IUSTI (university institute for industrial thermal systems) in Marseille, France.
He contributed to the development of software for predicting the spreading of wildfire. He has a Master degree in fluid mechanics and non-linear physics from Aix Marseille University, France.
He has followed a solid formation in physics.

**99. Surface Gusts Interacting with Wildfires**

***Presenter:*** *Linn, Rodman, Los Alamos National Laboratory*
***Additional Author(s):***
*Jeremy Sauer*
*Jesse Canfield*
*Scott Goodrick*

Wildfire behavior is known to be affected by local wind speeds and most fire behavior models represent fire spread and intensity as a function of wind speed. Numerous models and correlations describe the fact that as the mean wind increases fire spread rate generally increases. Researchers are making progress in understanding some of the mechanisms in which the local conditions such as fuel density, topography, fireline shape and flame length determine fire response to wind speed under relative steady and idealized conditions. Unfortunately, much less work has been focused on dynamic wind scenarios or the role of turbulence and local ambient wind fluctuations. One such dynamic wind scenario is when surface gusts, such as those caused by a sea breeze or thunderstorm downwashes, interact with a fireline. In these scenarios fires have been observed to have drastic changes in behavior. It is unclear how much of the changes in fire behavior are due to the dynamic nature of the event and how much can be attributed to just a change in wind speed. In addition to noteworthy changes in wind velocity, there are significant changes in turbulence, ambient vorticity and wind shear. A numerical coupled fire/atmosphere model FIRETEC is used to explore potential significance of these dynamic aspects when fires are exposed to these surface gusts or density currents. Results suggest that there could be a significant role in upwind vegetation structure in determining the acceleration of the fires exposed to these gusts. Cross-wave vorticity, especially near the leading edge of a gust wave, has a strong impact on near surface wind shear and thus on the fire spread rate. These explorations also illustrate the ways that the dynamic aspects of the winds can change the character of the fire/atmosphere interaction at the front of the fire. These numerical explorations are certainly not a substitute for field observation, but they do suggest new relationships that can be investigated with field observations in the future.

**Keywords:** fire behavior, dynamic winds, density currents

**Bio:** Rodman Linn is the team leader for the Atmospheric Modeling team in the Earth and Environmental Sciences Division at Los Alamos National Laboratory. Rodman has a BS, MS, and PhD in Mechanical Engineering and has been performing coupled wildfire/atmosphere modeling since 1995.

**100. Assessing Large Fire Behavior With Fundamental Fluid Dynamics Theory**

***Presenter:*** *Sauer, PhD, Jeremy, Postdoc, Los ALamos National Laboratory*
***Additional Author(s):***
*Jesse Canfield, Postdoc, Los Alamos National Laboratory*
*Rod Linn, Staff Scientist, Los Alamos National Laboratory*

The most readily visible aspect of large wildland fires is the fire plume itself. Plume height can be approximated in real time by visual inspection or satellite-based remote sensing. This work extends fundamental fluid dynamics theory characterizing plume height of the non-buoyant jet in a crossflow

(NB-JICF) scenario to the heated plume in a crossflow (HPICF) in order to suggest a relatively simple methodology for rapid assessment of large fire behavior and intensity from visual inspection or remote sensing of plume structure and height. A brief review of the non-dimensional Reynolds number and convective Froude number are presented in order to establish the analogy between prior work on the NB-JICF and the governing equations of large wildfire plumes in the atmosphere. Results of numerical investigations using the Higrad-Firetec model for idealized coupled atmospheric/wildfire scenarios are presented illustrating the potential impact of this simple methodology in assessment of fire intensity and changes in fire behavior. Caveats of this approach pertaining to atmospheric stability and atmospheric conditions are clarified and future work to overcome these hurdles is outlined.

**Keywords:** large fires, fire behavior, fluid dynamics theory, convective Froude number

**Bio:** Jeremy Sauer obtained his B.A. in Physics and Computer Science in 2002, and M.S. in Computer Science in 2005 from the University of Montana. During the latter stages of this time he worked for Systems for Environmental Management (SEM) as a computational scientist consulting for the USDA Forest Service RMRS in Missoula. From 2006-2013 he was employed at Los Alamos National Laboratory as a Graduate Research Assistant in the Computational Earth Sciences group of the Earth and Environmental Sciences Division while pursuing his PhD in Geophysical Fluid Dynamics from Florida State University. Having completed his PhD in 2013, he is now a postdoc at LANL, where his research focuses on high-performance computing, computational fluid dynamics, numerical solutions of partial differential equations, and modeling of coupled atmospheric and environmental dynamics. He is a lead developer of LANL's next-generation Higrad-Firetec model

**101. Characterization of firebrand geometry and flight dynamics**

***Presenter:*** *Tohidi, Ali, PhD Student, Clemson University*
***Additional Author(s):***
*Kaye, Nigel Berkeley, Associate Professor, Clemson University*

The generation of spot fires by the lofting and transport of firebrands can ignite homes, and create new fire fronts ahead of the main fire. There are a lot of models for the lofting of firebrands by a fire plume, their transport ahead of the fire by wind, and the ignition potential of the firebrands upon landing. However, these models can be improved through a better understanding of the model input conditions and through experimental verification of model behavior. This paper addresses these two problems. We begin with an analysis of laboratory measured ember size and shape data from full scale coniferous tree burns. The data in the literature shows that, for the trees tested, the firebrands are cylindrical with length to diameter ratios typically greater than one. Geometric analysis shows that the ember surface area scales on the firebrand mass raised to the 2/3rds power which is consistent with the published data. We show that the firebrand mass and aspect ratio are uncorrelated and that each can be reasonably well represented by a log-normal PDF. These PDFs can, therefore, be used to generate virtual embers for use in Monte Carlo simulations of ember transport. We also show that the ember size is only weakly correlated with the tree height (though there is a very limited range of tree heights tested in the literature).

The flight mechanics of cylindrical embers is then examined. A series experiments were conducted in which wooden cylinders were dropped in a zero wind environment and their landing position recorded.

The drop height was varied from 1.6 to 9.2 m and the initial angle of release was randomly varied. Each cylinder was dropped between 70 and 100 times per release height. For each drop the horizontal distance from the point directly below the release point was recorded and a PDF of radial travel distance was recorded. These PDFs are compared to theoretical PDFs generated using Monte Carlo simulations of the ember drop experiments in which the initial release angle was randomly varied.
This work is ongoing with plans for large scale wind tunnel testing this summer. The wind tunnel tests will include both the lofting and transport of model firebrands and will be used to verify current modeling assumptions.

**Keywords:** Spot fire; Firbrand; Monte-Carlo Simulation; Experimental Modeling

**Bio:** Ali Tohidi is a PhD research student of Civil Engineering at Clemson University. He received his B.S. in Civil Engineering from IAUCTB, Tehran, IRAN in 2009. He continued his studies at Sharif University of Technology where he obtained his M.Sc. in Civil Engineering at Hydraulic/Structures division on 2011. He's worked on wind induced gravity currents in aquatic canopy zones. He, then, moved to Clemson, SC and His current research focus is on wildfire spread, firebrand characterization and fire plume behavior. His corresponding research thrusts are Environmental Fluid Mechanics, FEM, CFD, Turbulence, Image/Signal Processing, Particle Tracking and Spectral Analysis.

## 102. Effects of Bark Beetle Attack on Crown Fuel Flammability and Crown Fire Potential in Lodgepole Pine and Engelmann Spruce Forests

***Presenter:*** *Alexander, PhD, RPF, Martin, Adjunct Professor, Department of Renewable Resources and Alberta School of Forest Science and Management, University of Alberta*
***Additional Author(s):***
*Page, Wesley, PhD Candidate, Department of Wildland Resources, Utah State University, Logan, UT*
*Jenkins, Michael, Associate Professor, Department of Wildland Resources, Utah State University, Logan, UT*

Large wildland fires in conifer forests typically involve some degree of crowning, with their initiation and spread dependent upon several characteristics of the canopy fuels. Recent outbreaks of mountain pine beetle in lodgepole pine forests and spruce beetle in Engelmann spruce forests have affected vast areas across western and northern North America, which have subsequently produced forests containing relatively large amounts of dead or "bark beetle-altered" canopy fuel. Given that the transition to crowning represents an important threshold in terms of large fire growth and wildland firefighter safety and effectiveness, a better understanding of the potential role of bark beetle-altered foliage in altering crown fire initiation and spread is needed. This presentation will provide an overview of a recently completed (May 2014) Ph.D. thesis project by the senior author dealing with the measurement and characterization of the changes in crown fuel flammability caused by recent bark beetle attacks and consequently the implications of these changes on crown fire potential in these affected forest types.

**Keywords:** canopy fuel flammability, fire behavior models, foliar moisture content.

**Bio:** Dr. Marty Alexander retired in November 2010 as a Senior Fire Behavior Research Officer with the Canadian Forest Service stationed at the Northern Forestry Centre in Edmonton, Alberta, following 34.5 years of public service and now also serves as an Adjunct Professor at the University of Alberta. His research and technology transfer has focused on practical applications of wildland fire behavior knowledge. His work over the years has taken him to many parts of the world, including the continental USA and Alaska, Australia, New Zealand, Portugal, Greece, Italy, Fiji, and Turkey, as well as every Canadian province and territory.

**103. The Changing Culture in Wildland Firefighting Safety—an Examination of 1994-2013 Entrapment Rates**

***Presenter:*** *Loveless, PhD, Bob, , Washington Institute*
***Additional Author(s):***
*Hernandez, Adam, Captain, Sierra National Forest Kings River Hotshots*

The tragic fatality events of the mid-1990s and subsequent studies led to a concentrated effort to increase safety in the US federal wildland firefighter community beginning in 2000. Addressing human factors (HF) as a causal agent in accidents was a major focal point for this cultural change. To examine the effectiveness of this change, we hypothesized a decline in firefighter entrapment rates after implementation. Seasonal data on entrapment numbers and exposure amounts was collected on a national level for federal and non-federal wildland firefighting agencies for the years 1994-2013. The annual rate of wildfire entrapments (number/1000 person-hours exposed on the fire line) was estimated using a generalized linear mixed model with poisson errors. Since program inception in 2000, rate ratio estimates indicate a 70% reduction in the annual entrapment rate for all (federal and non-federal) wildland firefighters after controlling for variation in annual acres burned, number of fires and exposure time. A similar 76% reduction in entrapment rates was estimated in the federal firefighter only model. Other non-HF changes since 2000 such as improved weather forecasting may account for some of this reduction. We recommend continuation of the HF focus as a significant contributor increasing safety in the firefighting culture and suggest data collection improvements for continued monitoring.

**Keywords:** Human factors, culture change, entrapment, firefighter safety

**Bio:** Bob Loveless has been an instructor in the Technical Fire Management program with Washington Institute for over 25 years. He is a retired professional structural firefighter formerly with the Kent, WA Fire Department. He owns and operates Prairie Sage Analytics LLC, a statistical consulting firm.

**104. Developing wildland firefighters' leadership qualities through awareness-based processes: A qualitative investigation**

***Presenter:*** *Waldron, PhD, Alexis, Post-Doctoral Scholar, Oregon State University*
***Additional Author(s):***
*Ebbeck, Vicki, Associate Professor, Oregon State University*

The safety and development of wildland firefighters as leaders and professionals has been at the forefront of the call for more human factors research that began in 1995. Despite many advances in human factors training, there has been a continuously increasing fatality trend line. Moreover, fire seasons are on average 78 days longer than past decades (Westerling, Hidalgo, Cayan, & Swetnam, 2006) and budget constraints are being placed on fire managers to do more with fewer available

resources in terms of man power, tractors, engines, aircraft (USDA, 2012), and managing an increasing wildland urban interface. As is evident from fire fatalities, the need for tools and methods of understanding and developing the capacity of wildland firefighters to handle the dynamic pressures of the physical and social environments is needed more than ever.
The purpose of this study was to explore a mindful and self-compassionate awareness program that addressed these pressures. The program was designed specifically for the wildland fire environment with wildland fire personnel. The program was based on the use of a conceptual tool to refocus awareness and move self-compassionately through key aspects of present moment happenings with the self, others, and the surrounding environment during a 6-month period. A sample of federal fire managers and crew supervisors (N=8) located at three locations in the Western United States was used to assess the program. Through an action research methodology, program receptiveness, implementation, and suggested improvements were explored. Key findings closely aligned with other mindfulness, self-compassion, and positive psychology interventions. Participants reported positive outcomes through using mindfulness and self-compassion processes through a variety of stressful, dynamic life situations both personally and professionally. Regarding the intervention aspect, participant experience was influenced by several factors including person-activity fit, age, and career and life experience. In general participants had varying degrees of adherence, unique implementations, and favored its adoption and further exploration in wildland fire curricula. Future directions will be discussed.

**Keywords:** decision-making, SHARP, leadership

**Bio:** Dr. Waldron has been a wildland firefighter for 10 seasons on hand crews, engine crews, helitack crews, and heli-rappel crews, and has served as a human factors specialist for fatality incidents. Based on hers and others near misses/accidents and leadership experiences in fire she has developed a drive to build and enhance fire trainings and tools based on what firefighters have expressed is important. Dr. Waldron has used the tools developed with firefighters not only to develop firefighters personally and professionally, but also various athletes, challenge course facilitators, and other outdoor professionals.

### 105. Evaluating Sprinkler Efficacy for Wildland Fire Protection Programs in Fairbanks, Alaska

***Presenter:*** *Barnes, RPF, Devon, Masters of Science Candidate, University of Alberta*
***Additional Author(s):***
*Flannigan, Mike, Professor, University of Alberta*
*Miller, Eric, Fire Ecologist, Bureau of Land Management*

Many fire agencies goal is to allow fires opportunity to burn freely while maintaining protection of values at risk. To meet these objectives a new strategy to fire control is necessary. This is particularly important as wildland fire management organizations reach their resource limits of people, pay and equipment. Sprinkler protection programs alleviate fire resource scarcity by reducing the resources required per unit area. The area protected by each sprinkler can be extrapolated for strategic fire management planning.

The immediate protection from sprinklers by wetting the fuel surface is known, but the water saturation effect is rarely considered. How much sprinkler watering is needed to treat a given fire hazard? This study evaluates sprinklers' ability to alter fuel moisture content in Boreal forests around Fairbanks, Alaska. The experiment tested a variety of sprinkler watering treatment levels at eight research sites. Each research site contained twelve treatment plots having four subsample stations. The subsample stations measured the amount of water received (independent variable) and the change in fuel moisture content (dependent variable). The moisture contents are then converted into Fire Weather Index (FWI) values to show the fire hazard reduction.

The research intent is to counteract moisture loss using sprinklers to mitigate drought stress in live and dead fuels to inhibit combustion. The results indicated watering treatment effectiveness to a point of diminishing return. A regression curve is developed to quantify the water use efficiency of the sprinkler treatments. This information will allow fire managers to control when and where wildland fires can occur.

**Keywords:** Sprinkler protection, Fire Weather Index, Fuel moisture content

**Bio:** During Devon's undergraduate education, he spent his summers working on an initial attack fire crew. In 2009, Devon graduated from Lakehead University's Faculty of Forestry. After three years of forests practice, Devon received his Registered Professional Forester status.
In 2012, Devon met Dr. Flannigan and wrote a proposal to research sprinkler efficacy. The research intent is to alleviate drought stress by watering hazardous fuel beds to inhibit combustion. Devon believes sprinklers can meet both protection and ecological objectives around values at risk.

### 106. From "Dude" to "Yarnell": a retrospective Look at 24 Years of Wildfire Fatalities in the U.S. (1990 - 2013)

*__Presenter:__ Mangan, Dick, President, Blackbull Wildfire Services*

This presentation will present an overview of the wildland fire fatalities that have occurred from 1990 - 2013, looking at specific causes, classes of firefighters killed, geographic areas where the fatalities occur, and trends over the 24 years. It will identify recurring fire safety problem areas, and offer ideas to improve firefighter safety and reduce fatal events on wildfire incidents.

**Keywords:** Wildfire fatalities, wildfire deaths

**Bio:** Dick has more than 40 years experience in wildland fire, both with the US Forest Service and as a private Consultant. He has wildfire qualifications as an Operations Section Chief and Safety Officer, has worked as an Expert Witness in the US and Australia, and has authored major Technical Reports and a Special Paper on wildland fire fatalities. He has served on numerous wildland fire fatality Investigation Teams across the US.

### 107. Coupled Weather-Fire Modeling of Landscape-scale Wildland Fires using Satellite Active Fire Detection Data: Application to Firefighter Safety

*__Presenter:__ Coen, PhD, Janice, Project Scientist, National Center for Atmospheric Research*
*__Additional Author(s):__*
*Schroeder, Wilfrid, Research Associate Professor, University of Maryland*

Large wildfires can cover hundreds of thousands of acres and continue for months, varying in intensity as they encounter different environmental conditions, which may vary dramatically in time and space during a single fire. They can produce extreme behaviors such as fire whirls, blow-ups, bursts of flame along the surface, winds ten times stronger than ambient conditions, and deep pyrocumuli – all of which result from the interactions between a fire and its atmospheric environment and are beyond the capabilities of current operational tools. The duration of such events poses a prediction challenge, as meteorological models lose skill over time after initialization. Moreover, validation data for such models is limited and fire mapping and monitoring has been done piecemeal with infrared imaging sensors producing 12-hourly maps of active fires with nominal 1 km pixels, complemented by sub-hourly observations from geostationary satellites at coarser resolution and other valuable but non-routine tools such as airborne infrared mapping.

Coupled weather-wildland fire models tie numerical weather prediction models to wildland fire behavior modules to simulate the impact of a fire on the atmosphere and the subsequent feedback of these fire-induced winds on fire behavior. Our approach uses one such coupled model, the Coupled Atmosphere-Wildland Fire Environment (CAWFE) Model, combined with spatially refined (375 m) satellite active fire data derived from the Visible Infrared Imaging Radiometer Suite (VIIRS), which is used for initialization of a wildfire already in progress in the model and evaluation of its simulated progression at the time of the next pass.

Case studies of landscape-scale wildland fires will be presented to illustrate our current capability to model the unfolding of large fire events -- foremost for research and understanding, but also to assess their suitability as a predictive tool. Over a wide range of conditions, model results show rough agreement in area, shape, and direction of spread at periods for which fire location data is available; additional events unique to each fire such as locations of sudden acceleration, flank runs up canyons, and bifurcations of a fire into two heads; and locations favorable to formation of phenomena such as fire whirls and horizontal roll vortices. Results show that using a cycling forecasting approach, in which a sequence of CAWFE simulations initialize the fire 'in progress' with VIIRS data and updated atmospheric analyses can overcome several forecasting issues and allow good representation of fire growth from first detection until extinction.

**Keywords:** wildland fire modeling, growth forecasting, satellite data assimilation, predictability, case studies

**Bio:** Dr. Janice Coen is a Project Scientist at the National Center for Atmospheric Research in Boulder, Colorado. She studies fire behavior and its interaction with weather using coupled weather-fire computer simulation models and by analyzing infrared imagery of wildfires and prescribed fires. 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 has been a member of the Board of Directors of the International Association of Wildland Fire and is currently an Associate Editor for the International Journal of Wildland Fire.

**108. Changes to Probability of Ignition in Canopy Fuels Following Mountain Pine Beetle Attack**

***Presenter:*** *Cohn, Greg, Forester, US Forest Service*

***Additional Author(s):***
*Parssons, Russell, Research Ecologist, US Forest Service*
*Jolly, W. Matt, Research Ecologist US Forest Service*

Mountain pine beetle (Dendroctonus ponderosae Hopkins) is an endemic insect that effects pine species throughout the North American Rockies. In the past decade, changes in stand structure have contributed to a massive outbreak that has affected millions of acres in North America. Recent studies have indicated that infected trees have altered burning characteristics compared to uninfected trees. These studies, however, have tested ignition properties using heat sources that do not exist in the wildland environment. No work has yet demonstrated how this change affects ignition in a wildland setting or how this knowledge can be applied to operational models. Probability of ignition measures the chance of an ember igniting a receptive fuel bed and is a common tool used by fire managers to anticipate when new fire starts or spotting is likely. In this study we reproduced the conditions of an ember landing in pine needles of a mountain pine beetle affected tree using a single match. We then created a probability of ignition table from a logistic regression to represent these altered canopy fuels. We found that needles with moisture contents below 18% ignited greater than 50% of the time from a single match. Reported moisture contents of affected needles average ~12%, indicating that infested trees may be vulnerable to ignition from falling embers.

**Keywords:** mountain pine beetle, probability of ignition, spotting

**Bio:** Greg Cohn is a Forester at the Forest Service Fire Lab in Missoula. He started working for the Forest Service Fire Lab in 2006 while finishing his undergraduate degree at the University of Montana. There he earned a B.S. in Resource Conservation, a minor in Wildland Restoration, and a certificate in GIS from the School of Forestry. Hooked on skiing and hiking, he has stayed in Missoula as a fuels and post fire assessment specialist at the Missoula Fire Lab. He has contributed to work on post fire severity, fuel mapping, insect disturbance, fire behavior modeling, and recently published a paper on relationships between moisture, chemistry and ignition of needles during mountain pine beetle attack.

### 109. Prescribed fire effects on field-derived and simulated forest carbon stocks

***Presenter:*** *Vaillant, PhD, Nicole, Fire Ecologist, Forest Service - PNW - WWETAC*
***Additional Author(s):***
*Reiner, Alicia, Fire Ecologist, AMSET*
*Noonan-Wright, Erin, Fuels Specialist, WFM RD&A*

To better understand the impact of prescribed fire on carbon stocks, we quantified aboveground and belowground carbon stocks within five pools (live trees and coarse roots, dead trees and coarse roots, live understory vegetation, down woody debris, and litter and duff) and potential carbon emissions from a simulated wildfire before and up to 8 years after prescribed fire treatments. Total biomass carbon (sum of all the pools) was significantly lower 1 year post-treatment than pre-treatment and returned to 97% of pre-treatment levels by 8 year post-treatment primarily from increases in the tree carbon pool. Prescribed fire reduced predicted wildfire emissions by 45% the first year after treatment and remained reduced through 8 year post-treatment (34%). Net carbon (total biomass minus simulated wildfire emissions) resulted in a source (10.4–15.4 Mg/ha ) when field-derived values were compared to simulated controls for all post-treatment time periods. However, the incidence of potential crown fire in

the untreated simulations was at least double for the 2 year and 8 year post-treatment time periods than in the treated plots. We also compared field-derived estimates to simulated values using the Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS). In our validation of FFE-FVS to predict carbon stocks, the model performed well for the total biomass carbon (4% difference); however, there was great variability within the individual carbon pools. Live tree carbon had the highest correlation between field-derived and simulated values, and dead tree carbon the lowest correlation and highest percent differences followed by herb and shrub carbon. The lack of trends and variability between the field-derived and simulated carbon pools other than total biomass indicate caution should be used when reporting carbon in the individual pools.

**Keywords:** California, Fire and Fuels Extension to the Forest Vegetation Simulator, Prescribed fire, Carbon stocks, Model validation

**Bio:** Nicole Vaillant is a fire ecologist at the Western Wildland Environmental Threat Assessment Center (WWETAC) and has worked for the Forest Service since 2001. Prior to coming to the Center Nicole worked as a seasonal wildland firefighter, including a season with the Redding Hotshots, and was a fire ecologist with Adaptive Management Services Enterprise Team. Her current interests include characterizing fire behavior at multiple scales, fuel treatment effectiveness, and risk analysis.

**110. Protecting the Protected: Designing a Fuels Treatment Plan in Arizona's Huachuca Mountains to benefit the Threatened Mexican Spotted Owl**

***Presenter:*** *Hollingsworth, LaWen, Fire Behavior Specialist, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Lab*
***Additional Author(s):***
*Wallace, Timothy, Forester, Rocky Mountain Research Station*
*Brewer, Debbie, Wildlife Biologist, Fort Huachuca*
*Hedwall, Shaula, Senior Fish and Wildlife Biologist, U.S. Fish and Wildlife Service*

The Huachuca Mountains are one of the many sky island mountain ranges located in southern Arizona that are host to numerous species of interest, including the Mexican Spotted Owl (Strix occidentalis lucida). The Mexican Spotted Owl (MSO) is a federally protected species under the Endangered Species Act and therefore efforts to manage habitat for the species' recovery is an important consideration for land managers. The resiliency of existing vegetation in this fire-adapted ecosystem has been compromised by decades of fire suppression that have altered forest structure, modified species composition, and led to increased fuel loading. Potential fire effects were exemplified by the Monument Fire that burned in the Huachuca Mountains in June of 2011; fueled by drought, heavy herbaceous fuel, and sustained high winds, this fire affected approximately 11 of 13 MSO Protected Activity Centers (PAC) within the Coronado National Forest.

The purpose of this project is to alter vegetation and surface fuels to reduce the potential of widespread high severity, stand-replacing fire within the Huachuca Mountains on the Fort Huachuca Army Installation while maintaining and developing habitat conditions conducive for the owl, other threatened and engendered species, and their prey. A wildfire within the Fort's boundary has the potential to drastically alter forest characteristics from that of the current multi-storied, multi-aged pine and oak habitat used by the MSO. The objective of this project was to develop a fuels treatment plan

based on landscape fire simulations to allow Fort Huachuca to treat minimum area for maximum benefit and produce forest structure and fuel characteristics that reduce the likelihood future wildfires will cause large, rapid changes in biophysical conditions in and around designated MSO PACs while still maintaining habitat for all other threatened and endangered species and their prey.
We developed a fuels treatment plan for Fort Huachuca based on the primary objective of modifying future wildfire behavior within and adjacent to the MSO PACs using two different sources of data, 1) LiDAR data and 2) LANDFIRE data as modified by local specialists. Simulation outputs were compared for data derived from LiDAR versus modified LANDFIRE data to evaluate differences in predicted fire behavior. Using this data, we identified strategically-placed fuel management units that would be mechanically thinned and burned to change the vegetation structure and biomass distribution to modify potential fire behavior and provide more resilient habitat for the MSO and other species of concern.

**Keywords:** fuels management, fire behavior, Mexican Spotted Owl

**Bio:** LaWen Hollingsworth is a Fire Behavior Specialist for the Fire Modeling Institute at the Rocky Mountain Research Station in Missoula, Montana. Professional interests include observing and analyzing fire behavior and fire effects, data preparation and calibration, and designing projects in multiple vegetation types. Most of her federal career has been spent in the field working as a Fire Ecologist, firefighter, and conducting long-term vegetation monitoring in upland and riparian systems. She has a M.S. from the University of Montana in Forestry/Fire Ecology and a B.S. from the University of Idaho in Forest Resources.

### 111. How much carbon is really lost in forest fires: findings from 40 Eucalyptus forests of southern Australia

***Presenter:*** *Weston, PhD, Chris, Senior Lecturer, University of Melbourne*
***Additional Author(s):***
*Volkova, Liubov, Research Fellow, University of Melbourne*

Fuel reduction burning is a common management practice in the Eucalyptus forests that extend across large areas of southern Australia. This study reports the findings from forty fuel reduction burns in these forests where biomass was accurately measured before and immediately after fire to derive fuel loads. Experimental sites extended from warm temperate forests (Queensland) to cool temperate (Victoria) and included dry woodlands (South Australia and Tasmania). Fire intensities generally fell within the range of 200-800 kW h-1. Across this broad range of forests of widely differing productivity (200-800 g m-2 year-1) the percentage of mass loss from six fuel categories was remarkably consistent across the fuel reduction burns. The litter layer and shrub components generally accounted for more than 50% of fuels consumed while coarse and woody biomass contributed to 20-40% of fuels. The fate of coarse fuels following prescribed fire has not been well quantified in Australian forests and these results signal the need to account for these fuels in future fire behaviour and emissions models. Woody fuels generally smoulder for hours and days after fire, with emissions dominated by the potent greenhouse gas methane, compared with the minutes for fine fuel combustion that is generally dominated by $CO_2$ emissions. The results of the study will allow fire managers to be more confident in the carbon balance outcomes of fuel reduction burning. They also open the possibility for better estimating fuel loads and their characteristics from relationships between forest net primary productivity (NPP), forest age and time since last fire. Reducing the risk of wildfire at a landscape scale is a top priority for fire-land

managers in Australia and this research offers the prospect of generating more accurate fuel maps for use in fire prediction, fire management and emissions modelling, as well as understanding the impacts of climate variability on fuels.

**Keywords:** fuels, emissions, biomass

**Bio:** Chris Weston is Senior Lecturer in the School of Forest and Ecosystem Science at the University of Melbourne's Creswick campus. He studies forest biomass, carbon and nutrient cycling and maintains long-term studies of the recovery of ash-type eucalypts from stand replacing fires in 1983. He has authored over 30 peer reviewed articles and book chapters on forest productivity and fire impacts on carbon and nutrient cycling.

**112. Field Experiments and Modeling for the Assessment Fuel Treatment Effectiveness in Reducing Wildfire Intensity and Spread Rate**

***Presenter:*** *Mueller, Eric, Phd Student, University of Edinburgh*
***Additional Author(s):***
*Skowronski, Nicholas, Research Forester, USDA Forest Service*
*Clark, Kenneth, Research Forester, USDA Forest Service*
*Kremens, Robert, Associate Research Professor, Rochester Institute of Technology*
*Gallagher, Michael, USDA Forest Service, Forestry Technician*
*Thomas, Jan, Phd Student, University of Edinburgh*
*El Houssami, Mohamed, Phd Student, University of Edinburgh*
*Filkov, Alexander, Associate Professor, National Research Tomsk State University*
*Butler, Bret, USDA Forest Service, Research Scientist*
*Hom, John, USDA Forest Service, Biological Scientist*
*Mell, William, USDA Forest Service, Research Combustion Engineer*
*Simeoni, Albert, BRE Research Chair in Fire Safety Engineering, University of Edinburgh*

A key aspect of wildfire mitigation strategy in the United States is the use of fuel treatments, conducted both through prescribed fire and mechanical means. At present, however, scientific quantification of the effects of such efforts, as they impact fire behavior (e.g., intensity, fire spread, heat fluxes, fire brand generation), is limited. The project presented here is aimed at addressing this knowledge gap by taking a combined experimental and numerical (modeling) approach to quantifying fuel treatment effectiveness in the New Jersey Pine Barrens. On the experimental side, evaluation of fire behavior was conducted through the observation and measurement of two operational prescribed fires. These fires, intended to compare two bounding levels of fuel treatment, were carried out in consecutive years. Assessment of the fire-environment during each burn was achieved through the 10 Hz measurement of gas temperatures, heat fluxes, and 3-dimensional turbulence at numerous locations. Along with the collection of fire-related data, detailed quantification and characterization of the fuel was conducted in both the pre- and post-burn environments. A combination of airborne and terrestrial Light Detection and Ranging (LiDAR) estimated the spatial distribution of fuel throughout the block. This data was coupled with information from destructive field sampling, which was conducted at a number of locations within the block. For the first fire, a preliminary assessment of the timeline of fire progression is presented, with the intent of linking both local fuels (loading and consumption) and weather (turbulent transfer rates) to the observed fire behavior. For the second, more recent, fire, only a general

overview is given. Additionally, initial efforts to model the progression of the first fire, using the Wildland-urban interface Fire Dynamics Simulator (WFDS), a detailed physical numerical model, are presented. As part of the overall plan for the study, the experiments were set up in such a way as to provide data which could be easily translated to inputs and comparison points for fire modeling applications. Fuel distributions obtained from LiDAR are directly input to the model, and measurements of the fire-environment are used as comparison points. By linking a detailed physical model to real fire data in such a way, this coupled approach demonstrates the potential use of such models for understanding the complexities of wildfire behavior.

**Keywords:** fire behavior, fuel treatment effectiveness, prescribed fire, experimental measurement, fire modeling

**Bio:** Eric Mueller is a second year PhD student at the University of Edinburgh, studying wildland fire behavior. He received a B.S. from Tufts University in 2010, and an M.S. in Fire Protection Engineering from Worcester Polytechnic Institute in 2012. His research is directed toward the numerical modeling of fire behavior. In particular, he is focused on the interaction of vegetation and wind, as well as the impact of fuel treatment measures.

### 113. An application of risk analysis to support and evaluate wilderness fire management decisions

***Presenter:*** *Barnett, Kevin, The University of Montana*
***Additional Author(s):***
*Venn, Tyron, Associate Professor of Natural Resource Economics, College of Forestry and Conservation, The University of Montana*
*Miller, Carol, Research Ecologist, Aldo Leopold Wilderness Research Institute, USDA Forest Service Rocky Mountain Research Station*
*Parks, Sean, Landscape Ecologist, USDA Forest Service Rocky Mountain Research Station*

Inside many of the U.S. federally designated wilderness areas, fire suppression is the dominant management strategy largely due to the risk that fires pose to resources adjacent to the wilderness boundary. Not only does continued fire suppression run counter to the intents of wilderness management, but opportunities to exploit the benefits of wilderness fire as a risk-mitigation tool are foregone when ignitions are suppressed. Little attention has focused on the fuel treatment benefits of wildfire in terms of its effects on the future decision-space for management of unplanned ignitions. In this case study, the outputs from multiple wildfire simulation models were used to map the likelihood of wilderness fire escape for two different landscape scenarios: (1) an observed landscape reflecting fuel conditions as a result of actual wildfire management strategies; and (2) a ‘treated’ landscape that reflects hypothetical fuels and vegetation assuming recently suppressed ignitions had been allowed to burn. First, wildfire spread and behavior for suppressed ignitions in a single year in the Bob Marshall Wilderness Complex, Montana, USA, were retrospectively simulated. Hypothetical fuels layers were created for each retrospectively suppressed fire by modifying the observed pre-fire fuels conditions within the simulated perimeter based on modeled burn severity. The observed and hypothetical fuels layers were then used as inputs in a large wildfire modeling system commonly used in quantitative wildfire risk analyses. Differences in the likelihood of future wilderness fire escape between the observed and treatment landscape scenarios were examined for both inside the simulated area burned by the suppressed ignitions (i.e. the treated area) and the area within several kilometers outside of the

simulated wildfire perimeters (i.e. the off-site effects). Results suggest that larger treated areas arising from ignitions closer to the wilderness boundary had the greatest effect on reducing the likelihood of wilderness fire escape within the treated area. The relationship between ignition location, fire size, and reduction in escape probability outside the treated area was variable. Fire and fuels managers can use this type of information during strategic decision-making and pre-season planning, as well as to evaluate the effectiveness of different risk-mitigation strategies based on how the strategies affect future opportunities to allow natural ignitions to burn.

**Keywords:** simulation modeling, fuel treatment, escape probability, decision-making

**Bio:** Kevin Barnett recently completed his graduate studies at The University of Montana, where he applied landscape fire risk models to evaluate wilderness fire management decisions.

### 114. Wildfire Interactions With Fuel Treatments in Sierra Nevada Forests: Consequences for Forest Structure and Understory Plant Diversity

***Presenter:*** *Stevens, Jens, Department of Plant Sciences, University of California, Davis*
***Additional Author(s):***
*Safford, Hugh D, Regional Ecologist, USDA Forest Service, Region V*
*Latimer, Andrew M, Associate Professor, UC Davis*

Wildfires in the yellow pine and mixed-conifer forest belt of the Sierra Nevada Mountains in California are increasing in size and severity, due to increased fuel loads that are the result of over a century of fire suppression. The most common management strategy in these forests is to implement fuel treatments in order to reduce fuel loads and decrease wildfire severity. We present the results from a large statewide study of fuel treatment-wildfire interactions, with specific focus on the ecological effects of these disturbances on forest structure and understory plant diversity. We sampled forest vegetation plots from twelve wildfires that burned into fuel treatments, as well as adjacent unburned fuel treatments and controls. We show that fire severity is dramatically reduced by fuel treatments, and that the degree of structural change in response to wildfire is much less in treated stands than in untreated, high-density stands. The effects of fuel treatments on patterns of shrub and tree regeneration in response to wildfire are contingent upon whether stands had previously been treated, with post-wildfire shrub recruitment highest in untreated stands and post-wildfire tree recruitment highest in treated stands. We found strong evidence that a continuum of forest canopy disturbance affects the diversity and composition of the understory plant community. Intermediate levels of forest disturbance, found in treated forests that subsequently burn in wildfire, had the highest understory plant diversity, relative to unburned forests or high-severity forests. We used information on species' evolutionary histories and traits to demonstrate that the proportion of the understory flora with evolutionary origins in mesic climates decreases with increasing fire severity, and that increased water stress in open-canopy forests following high-severity fire may filter understory species composition on the basis of leaf traits.

**Keywords:** Wildfires in the yellow pine and mixed-conifer forest belt of the Sierra Nevada Mountains in California are increasing in size and severity, due to increased fuel loads that are the result of over a century of fire suppression. The most common management

**Bio:** Jens Stevens is a finishing PhD student in Ecology at UC Davis. His research focuses on interactions between disturbance regimes and climate in forested ecosystems. Jens is particularly interested in understanding the mechanisms affecting plant diversity in forests, as well as how climate and management interact to limit invasive plant distributions in montane forests.