THE FIRE CONTINUUM CONFERENCE

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PREPARING FOR THE FUTURE OF WILDLAND FIRE

001. Regional Differences in Wildfire Risk in the United States from Systematic Operational Risk Assessments- How Risk is Conceived by Land Managers

Presenter: Erin Noonan-Wright, Fire Application Specialist, Wildland Fire Management Research Development and Application (WFM RD&A) and University of Montana, Fire Center, Ph.D Student
Additional Author(s): Seielstad, Carl, Fire and Fuels Program Manager/Associate Professor of the Fire Center, University of Montana

Risk management has become a significant component of federal wildland fire management as it now permeates federal wildland fire policy, agency-specific guidance, and pre-season national and regional direction. But what is the risk? And how do land managers conceive of risk? In this study, we explore patterns of wildfire risk across the US from the Systematic Operational Risk Assessments conducted by land managers on thousands of wildfire incidents. These assessments produce the actual risks used in the management of individual fires. Here, we provide a first-look at this risk using data mined from the federally-mandated wildland fire decision-making database, the Wildland Fire Decision Support System – WFDSS. The WFDSS Relative Risk Assessment is a systematic, semi-quantitative assessment of risk which integrates ratings of high, moderate, and low 'Values', 'Hazard', and 'Probability' derived from their contributory sub-elements to produce an overall assessment of risk for each wildland fire. For instance, a Hazard rating is a combination of low, moderate and high ratings of the sub-elements: Fuel Condition, Fire Behavior, and Potential Fire Growth. We analyzed 5,087 wildland fire incidents encompassing the years 2010 - 2017. We found large regional variations in Relative Risk along with variations in the sub-elements that contribute to it. For example, the West-Coast regions of the Northwest, and to a lesser extent Southern and Northern California strongly favor High Relative Risk by consistently favoring high risk in most of the sub-elements of the risk assessment, while the Southwest and Eastern Regions favor Low Relative Risk by disproportionately selecting low risk across sub-elements. Regions with moderate risk profiles such as Alaska, Rocky Mountains, and the Great Basin tend to use specific sub-elements more or less frequently than other regions. In Alaska, high risk ratings for Time of Season and Potential Fire Growth are chosen more frequently relative to national values, while Natural/Cultural Resources/Infrastructure Values and Proximity & Threat of Fire to Values are comparatively important in the Great Basin. By illuminating patterns of risk, we hope to stimulate examination of the social, cultural, and physiographic factors that influence conceptions of risk, and we expect that better understanding of the geographic diversity of risk may lead to advancements in risk management of wildfires. International audiences may find the factors that influence risk interesting and relevant to their own fire management programs.

Keywords: Fire Management, Risk, WFDSS, Relative Risk Assessment, United States

Bio: Erin Noonan-Wright currently works as a fire application specialist for the Wildland Fire Management Research Development and Application Group (WFMRD&A), supporting wildland fire incidents for land management agencies in the United States. She is also a graduate student at the University of Montana, Fire Center, and is pursuing a Ph.D. on fire management decision making on wildland fires. Most of her career was spent working with fire managers planning fuel treatments and managing long-term wildfires as a qualified Long-Term Analyst (LTAN). When not at work, she is a full-time mother of two young children who keep her on her toes.

002. Simulated vegetation and fire hazard at Eglin Air Force Base for 50 year time periods under multiple prescribed fire management scenarios using Fuel Classification and Characteristics System (FCCS) and a landscape-fire-succession model
Presenter: Jim Cronan, Research Forester, U.S. Forest Service
Additional Author(s):

Prescribed fire is an important land management tool used to reduce wildfire hazard and improve habitat in fire-adapted ecosystems across the southeastern US At Eglin Air Force Base, the largest forested military reservation in the United States, a substantial fraction (146,000 ha) is comprised of fire-dependent ecosystems with a natural fire rotation of 4 years. Navigating land use constraints imposed by competing interests (e.g., air quality, ecological integrity, endangered species habitat, and military training and operations) has been a key to replicating the natural fire regime with prescribed fire. Increasingly, more accurate assessments of the impacts of prescribed fire are necessary to justify and adequately plan burning operations. To help resource managers understand how changes in annual area burned with prescribed fire affects vegetation and fire hazard we simulated landscape-level vegetation using a landscape-fire-succession model (LFSM). We used the Fuel Characteristic Classification System (FCCS) to generate fuelbeds for simulations. State and transition models were developed to represent local vegetation dynamics. Ensemble simulations were produced for 50 year time periods under four management scenarios: 50% 75%, 100%, and 125% of current annual area burned. We present fuel characteristics and potential fire behavior from FCCS fuelbed maps for each scenario.

Keywords: fire modeling, fire ecology, fuels, fire behavior

Bio: Jim Cronan is a research forester at the Pacific Wildland Fire Sciences Laboratory in Seattle, Washington and PhD candidate at the University of Washington. His research interests include fuels dynamics related to fire and succession, fire behavior modeling, landscape fire succession models, ecological restoration, and using research to address management challenges.

003. The association between emerging fire occurrence hotspots and historical area burned in the boreal zone of Alberta, Canada
Presenter: Jen Beverly, Assistant Professor, University of Alberta
Additional Author(s):

Assessments of landscape fire risk are often informed by historical data on fire occurrence, such as ignition densities and ignition patterns, as well as general measures of historical fire frequency across broad areas, such as the average annual percent area burned. Due to the potential for complex spatial-temporal dynamics, historical fire activity may not necessarily represent expected future fire activity. For example, in northern boreal ecosystems, wildland fire disturbance may exert a negative feedback by regulating the timing and size of subsequent fire. The limiting effect of wildfire on subsequent fire occurrence and extent has been the focus of a number of recent studies in the United States and elsewhere. In some ecosystems, it may be reasonable to expect areas characterized by relatively low historical area burned to emerge as hotspots, where fire activity is increasing over time. This study explored whether or not emerging fire occurrence hotspots in the boreal zone of Alberta, Canada, coincided with areas characterized by relatively low historical percent area burned, in comparison with neighboring areas. Spatial statistical analysis was used to investigate trends in space-time fire occurrence patterns using a Government of Alberta database containing point fire locations reported between 1961 and 2014. Spatial variation in historical area burned across the same area was assessed using a separate database of historical fire burned areas (i.e., polygons) documented for the 1931 to 2014 period. Preliminary results indicate that emerging fire occurrence hotspots are associated with areas marked by a lower historical percent area burned in comparison with locations where fire activity has demonstrated a decreasing trend. The implications of these results for informing future fire hotspot analysis and strategic fire risk assessment methodologies is discussed.

Keywords:

Bio: Jen Beverly is an Assistant Professor of Wildland Fire in the Department of Renewable Resources, University of Alberta; and a former research scientist with the Canadian Forest Service. Jen's wildfire research activities have spanned over two decades during which she has published studies in the areas of fire ecology, fire behaviour, fire-climate interactions, fire risk assessment, wildfire evacuations and landscape values-at-risk mapping. She holds PhD and MSc degrees from the University of Toronto and a BES from the University of Waterloo. Jen's professional background includes government and private sector leadership roles, wildland firefighting (Ontario Fire Ranger) and applied landscape planning.

004. Forest Fire Prediction Modeling in Terai Arc Landscape of Lesser Himalayas using Maximum Entropy Method

Presenter: Amit Kumar VERMA, Technical Officer, Forest Research Institute
Additional Author(s): KALIYATHAN, NAMITHA NHANDADIYIL, TECHNICAL OFFICER, FOREST RESEARCH INSTITUTE, DEHRADUN, INDIA
BISHT, NARENDRA SINGH, PhD, PCCF (Retd.), ARUNACHAL PRADESH FOREST DEPARTMENT, INDIA
SHARMA, SATINDER DEV, PhD, SCIENTIST (Retd.), FOREST RESEARCH INSTITUTE, DEHRADUN, INDIA
NAUTIYAL, RAMAN, SCIENTIST, ICFRE, DEHRADUN, INDIA

Terai Arc Landscape (TAL) ecologically important region of the subcontinent is a mosaic of variety of land use and home to two most important tiger reserves (Corbett Tiger Reserve (CTR), Rajaji Tiger Reserve (RTR)), where anthropogenic habitat loss and forest fragmentation are major issues. The most prominent among these threats are forest fire since it impacts the micro and macro habitat characteristics and results in destruction of ecological processes. Moreover it aggravates man-animal conflict in the forest fringe areas. The lack of proper forest fire monitoring system in TAL is major management issues needs attention for the long term viability. Hence the present study was attempted using Maximum Entropy (MaxEnt) modeling to predict the potential areas under fire across the TAL and to identify key variables associated with fire occurrence. A total of n=200 spatiotemporally independent fire incidence locations were used after auto-correlation testing. Bioclimatic environmental variables were used along with other anthropogenic, topographic, Forest type/canopy density. Spatial multicollinearity of variables was tested where the variables with $r > 0.7$

were dropped from the analysis. The accuracy of the model was assessed using the area under the curve (AUC) and to assess the variables importance we adopted a jackknife procedure. Hence, 100 model predictions were averaged to produce a probability map. Additionally, for demonstration of high and marginal fire area, all values above 0.6 were categorized as high fire and those between 0.2 and 0.6 as marginal fire areas. Based on a 10% training presence logistic threshold, values below 0.2 were selected as no fire area. The results demonstrated that the dry deciduous forest having moderate canopy density and near to village was more impacted than other forest. Forest type, Isothermality, Actual Evapo-Transpiration, Forest canopy density, Precipitation of Seasonality and distance from village were highest contributors with 36.7%, 13.5%, 11.9%, 11.7, 5.9 and 5.5% respectively. The AUC score was (0.888) for the training data from our model, which indicates a moderate to excellent predictive ability of the model. The model predicted that about 7.32% area falling under high fire category followed by marginal fire 60.40%. The map resulted in the present modeling will serve as a bench mark for collection of presence and absence data on forest fire. The high fire areas predicted in the study can be used for prioritization to take up adaptive forest management strategy to mitigate forest fire and wildlife conflict in TAL.

Keywords: Forest Fire, Modeling, Terai Arc Landscape, Tiger, Maximum Entropy

Bio: He has Masters of Science degree in Forestry and awarded PhD degree in Forestry. He is actively working in the field of Forest Fire in Himalayan regions as well as in different Landscapes of India. The title of his PhD thesis is "Modelling Fire Hazard in Pine Zone of Uttarakhand".
His thesis was selected for student competition in "6th International Wildland Fire Conference 2015" held in South Korea. He has been awarded with Best Student Research award First Prize in "6th IWFC 2015".
His paper was selected for oral presentation in "5th International Fire Behavior and Fuels Conference".

005. California Burning: Developing Sustainable Solutions To Emerging Climate Challenges - Electric Utilities As A Case Study

Presenter: Martin Kurtovich, Senior Utilities Engineer, California Public Utilities Commission
Additional Author(s):

An important role for State Utility Commissions is ensuring that utilities operate in a safe and reliable manner and that investments to operate their system are shown by the utility meet the dual standards of being “prudent” and in the “public interest”.

When utilities are faced with the increasingly daunting challenge of address new circumstances due to climate change, determining how utilities meet these standards requires innovative policy processes and deliverables. Addressing the increased wildfire risk due to utility infrastructure is one such case study in how a State Utility Commission successfully addressed a new and significant operational condition for its’ utility industries, in this case specifically for its electric industry.

For the regulator, the regulated community, and wildfire stakeholders, the challenge is to determine appropriate measures in the short and long term. For the Commission, this requires concurrently assessing the benefits to safety and reliability and structuring in a financially sustainable framework.

In California, the 2007 Willow Fire in San Diego County and the Malibu Fire were the events that first raised awareness about the potential of electric distribution lines as ignition sources that combined with the right environmental conditions can result in massive wildfires. Many saw that the changing seasonal fire conditions would leave utility assets vulnerable and at times a public safety threat.

In 2017 the California Public Utilities Commission, working collaboratively with CalFire, California electric utilities and local communities, completed the development of a new regulatory framework to establish wildfire as a regulatory priority and setting the direction for utility wildfire policy in the West.

This presentation gives an overview of the recent development of this framework consisting of a California Fire Risk Map for Electric Utilities, the adaption of new regulations to improve transparency and effectiveness of utility wildfire activities and investments, and a State Working Group to more fully flesh out an asset management continuum that combines the science, policy, and regulations that reduces wildfire risks and better enables communities to respond to wildfire events.

Keywords: wildfire, ignition sources, electric, utilities, regulation, policy

Bio: Martin Kurtovich is a senior engineer in the Safety and Enforcement Division of the California Public Utilities Commission (CPUC). At the CPUC, Martin's duties include providing technical support to policy and regulatory initiatives on utility safety, critical infrastructure protection and wildfire risks.

006. GridFire: Open Source Fire Behavior Modeling in the Cloud

Presenter: Gary Johnson, Senior Scientist, Spatial Informatics Group
Additional Author(s): Saah, David, PhD, Managing Principal, Spatial Informatics Group
Moritz, Max, PhD, Associate Cooperative Extension Specialist, UC Berkeley

GridFire is an open source fire behavior model designed for speed and transparency. It can be installed on a desktop, laptop, or server computer running any modern operating system and is controlled through an easy to use web interface. If the computational requirements of a large fire simulation exceed the capabilities of a single machine, GridFire may be installed on a server cluster to distribute the workload over multiple computers. The same web interface is used to control both single machine and cluster-based installations.

To ensure that its calculations are transparent to both programmers and non-programmers alike, GridFire is written in a style known as Literate Programming. Instead of black box computer code buried in numerous poorly documented files, GridFire is written like a descriptive essay on fire modeling. All of the rationalization behind its fuel model definitions, ignition logic, and spread calculations are laid out in a clear human-readable format with sections, tables, figures, latex formulas, literature citations, and embedded source code snippets. This essay is directly compiled to produce the GridFire executable.

As inputs, GridFire takes the standard LANDFIRE topography and fuels data (or equivalent raster layers provided by the user) and weather conditions that may be input directly, sampled from provided ranges, or looked up automatically from available online weather records. It then simulates fire ignition and spread over landscapes like popular software packages, such as FARSITE and RANDIG. Individual fires may be simulated as burning for a fixed number of hours and the resulting fire perimeter, burn type, flame lengths, fire line intensity, and spread rates examined under different weather conditions. However, GridFire's forte lies in large scale Monte Carlo simulation, in which hundreds, thousands, or even millions of fires are simulated and analyzed in the aggregate.

Using this system, Spatial Informatics Group (SIG) was able to run over 100 million 1-hour fire simulations under extreme historical weather conditions for the state of California using a cluster of relatively inexpensive computers in less than three days once the model inputs had been prepared.

This presentation will discuss the details of the GridFire system, including its software architecture and the published fire ignition and spread algorithms it implements. Additionally, we will discuss how it was used to create updated statewide fire risk maps for California using a large scale Monte Carlo simulation approach. Future plans for the software and avenues for collaboration will also be discussed.

Keywords: fire modeling, fire behavior, raster-based models, open source software, scalable architectures, cloud computing, Monte Carlo simulation, Clojure, PostGIS, literate programming

Bio: Dr. Gary Johnson is a computational scientist with over ten years of experience designing, building, and using custom environmental modeling systems. His research and development work has focused on wildfire modeling, extreme weather statistics, spatial ecosystem service flow networks, decision support systems, risk assessment and uncertainty modeling, data mining, and machine learning. As a senior scientist with Spatial Informatics Group (SIG), he enjoys finding new ways to use advanced computational techniques to solve meaningful environmental problems.

007. Prescribed Burn Decision Support Tool (PB DST): An Essential Process to Support Your Decision Making

Presenter: Brian Levine, Senior Fire Management Officer- Prescribed Fire, ACT Parks & Conservation Service
Additional Author(s): Hemer, Simon, Lead Ranger, NSW National Parks and Wildlife Service
Denman, Tom, Fire Management Officer, NSW National Parks and Wildlife Service
Farquhar, Scott, Operations Manager, ACT Parks & Conservation Service

Prescribed burning is an essential tool for the management of fire. Burns can be complex and involve many variables that pose high levels of risk. Fire planners develop detailed plans to minimize risk, however risk will never be completely eliminated. Burn escapes and shrinking burn windows due to climate change have highlighted the need for a standardised tool to deal with the risks associated with prescribed burning.

The Prescribed Burn Decision Support Tool (PB DST) has been developed in Australia but the principles on which it is based have a broader application, including North America. The PB DST is a risk assessment tool that assists practitioners to recognise and document the risks associated with a prescribed burn and identify appropriate controls in consistent, transparent, repeatable and quantifiable manner. Based on the Australian/ New Zealand risk framework, ISO 31000: 2009, Risk Management – Principles and Guidelines, the PB DST facilitates fire planners in describing the burn context, identifying risks and then determining the likelihood and consequence of potential escape and impacts from smoke. The tool also provides fire managers with risk mitigation advice and assists agencies with succession planning by nurturing robust decision making practices amongst developing staff.

The PB DST is applied to burn implementation in a complimentary role to the burn plan and is designed to be used prior to ignition to assess the relative risk of proceeding based on current and predicted weather. The tool has also been designed to be utilised for each day of ignition. The PB DST includes automated weather and predicted fire behaviour data which together are presented to an incident controller for endorsement.

Multiple agencies within Australia have been using the PB DST and it has been endorsed by the Australian Forest Fire Management Group. The aim is to reach consensus on a consistent National product.

The strength of the PB DST has been the demonstrated ability to consistently document decision making based on the best available information. This has been validated in Australia following several burn escapes and implementation of contentious prescribed burns. When prescribed burn reviews have occurred, the ability to present a detailed summary of the extensive decision-making process prior to, during and after the burn has been invaluable. Our experience using the PB DST has reinforced the notion that written documentation is better evidence for justifying decision-making.

Keywords: Prescribed Fire; Fuels Management; Smoke Management; Fire Behaviour

Bio: Brian Levine works for ACT Parks and Conservation Service in Australia and is responsible for the prescribed burn program.

From Detroit Michigan, his passion for fire management began while completing a B.S. in Forest Management from the University of Vermont. Brian worked with the US Forest Service for over 10 years serving in various roles and locations across the US. Brian attended the Fire Use Training Academy and completed a Master's Degree at the University of California, Berkeley. Brian moved to the Australian Capital Territory in 2012 where he is currently a Senior Fire Management Officer and Fire Behaviour Analyst.

008. Modelling an econometric function to predict prescribed burning costs
Presenter: Francisco Rodriguez y Silva, Professor of Forest Fires Sciences, University of Cordoba (Spain)
Additional Author(s): Michael Hand (USDA Forest Service, Rocky Mountain Research Station)

Modelling an econometric function to predict prescribed burning costs
Authors: Francisco Rodriquez y Silva (presenter), University of Cordoba (Spain); Michael Hand (USDA Forest Service, Rocky Mountain Research Station)
This paper presents an econometric tool to help decision makers determine the costs of applying prescribed fire in the forest landscape. The model includes a set of environmental variables and characteristics of the scenarios where the burning is applied, and controls for material and human resources necessary to carry out prescribed burning operations. The econometric modeling technique is then used to compare prescribed burning costs in the United States and Spain.
This technique is useful for understanding the costs of controlling the load of forest fuels, and for the creation and maintenance of operational scenarios related to the extinction and suppression of forest fires under safe conditions. Such an application requires landscape analysis that incorporates the multiple variables that affect in decision making in prescribed burning operations. The incorporation of the prescribed burns within the framework of the forest fire defense programs

requires a corresponding cost analysis in order to integrate prescribed burning into the total fire management program budget.
The selection of the appropriate variables directly related to the planning, execution and evaluation of prescribed burns in the forest landscape. The costs incurred during prescribed burns and the factors related to the spread of fire and ignition techniques can help determine the set of factors that predict prescribed burning costs per hectare. Observations of prescribed burns are derived from the execution of prescribed fire in forest environments, in which it has been decided to apply prescribed burns as a tool of forest management.
With the econometric model developed, the opportunities to apply predicted prescribed burning costs are demonstrated. Potential applications include supporting budgetary decision-making in the management of the prevention of forest fires and improving understanding of how budgetary tradeoffs in fire prevention may be related to suppression costs and firefighter safety during wildfire incidents. The developed econometric model has been programmed in C ++ and has the corresponding software for its use by fire incident managers alongside other existing decision support tools.

Keywords: Prescribed Burning. Costs, Econometric modeling.

Bio: Professor of Forest Fires Sciences of University of Cordoba (Spain). Forest Engineer. PhD. Master on Arts Economics. Master on Economics Research.

009. Can we have it all? Optimal burning regimes for management of fuel, carbon, water and vegetation

Presenter: Tina Bell, Associate Professor, University of Sydney
Additional Author(s): Gharun, Mana, Dr, Department of Environmental Systems Science, ETH Zürich, Zürich 8092, Switzerland
Possell, Malcolm, Dr
School of Life and Environmental Sciences, University of Sydney, Sydney, New South Wales 2006, Australia
Adams, Mark, Professor, Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorne, Victoria 3122, Australia

A large proportion of south eastern Australia is forested and most of this area is vital for supply of water to capital cities and regional centres and for ecological recharge of major river systems. The annual and long-term water yield from these catchments, as well as their carbon storage potential, are amongst the most valuable of all natural assets of state governments and agencies, including power and water utilities in Victoria, New South Wales and the Australian Capital Territory. Depending on forest type, forested catchments show major differences in the effects of fire intensity on subsequent stand and forest hydrology and modification of carbon stocks. These differences point to the capability of using different fuel reduction burning (FRB) strategies in different parts of catchment landscapes to mitigate the risks associated with loss of water yield and quality, carbon sequestration capacity and vegetation diversity. While the primary goal of FRB is for removal or reduction of fuel to minimise the risk of bushfire affecting life and property, we are investigating the possibility of refining fire management of forested catchments to encompass other risks. This approach is akin to 'precision land management' that has been developed and used in broadacre agriculture. The key features of this concept are to quantify variability, understand the environment and make sound predictions to continually improve or adapt practices to become more efficient. We are working towards building a practical framework and a predictive model combining and optimising competing outcomes for FRB.

Keywords: prescribed burning, fuel reduction, water, carbon, vegetation

Bio: Associate Professor Tina Bell lectures in fire ecology and plant physiology in the School of Life and Environmental Sciences at the University of Sydney. With funding from the Bushfire and Natural Hazards Cooperative Research Centre, she leads a research team investigating the effect of high and low intensity fire on soil, vegetation and ecosystem services such as catchment water yield. Other fire-related research done by the team includes the effects of smoke on seed germination and plant functioning, smoke composition and flammability of fuels.

011. Fire and Ecological Forest Management and Prescribed Fire- Perfect Together
Presenter: Bob Williams, Certified Forester, President Pine Creek Forestry LLC
Additional Author(s): Bob Williams CF

This presentation will focus on the long term use of prescribed fire and its integration with and ecological approach to forest management. We will explain and demonstrate how two farm families have lived on their 17,000 acre forest land within The Pinelands National Reserve while using controlled fire to sustain their resources and protect themselves from frequent wildfires for the past 100 years! The pinelands is a yellow pine forest found along the coastal plain of southern New Jersey and supports a pitch pine forest type which is one of the most pyrogenic forest types in all of north America! We will show how the use of controlled fire and ecological forestry has been used to sustain and restore the ecological integrity of these pinelands ecosystems and the many threatened and endangered species found in these forests as well the benefits of having fire safe forests and communities and improved timber use!
This land provides a unique example how people can successfully live with fire close to some of the most populous areas of the east coast of the United States!
This land will be contrasted with the many 100's of thousands of acres of unmanaged public lands adjacent to this private land. These nearby unmanaged lands, now pose significant threats from southern pine beetle and uncontrolled wildfire!
This unique large managed patch of private lands now shines as a great example of sustaining resilient forests and ecosystems as demonstrated by these lands receiving the 2017 NJ Dept Of Environmental Protection's "GOVERNOR'S ENVIRONMENTAL EXCELLENCE AWARD FOR HEALTHY ECOSYSTEMS.

Keywords: PRESCRIBED FIRE- ECOLOGICAL FORESTRY- RESILIENT FORESTS

Bio: Mr. Williams has over forty year experience in the area of forest management and the use of prescribed fire. His unique experienced of working for ten years in the pacific northwest and the last thirty years in the pine forests of southern New jersey has allowed him a unique perspective of fire in terms of the national scene!
He is a private lands forester and now assists more than 700 landowners throughout NJ with their forest mgt issue with a high focus on concerns for wildfire and the ecological forest management approach to forestry! He is the owner and president of Pine Creek Forestry LLC

012. The Ultimate Test of the Effectiveness of Fuel Management in the Wildland/Urban Interface
Presenter: Stephen Cornelsen, Resource Conservation Manager, Riding Mountain National Park, Parks Canada
Additional Author(s): Murphy, Scott, Fire Managment Officer, Waterton Lakes National Park, Parks Canada

On August 11th, 2017, a high intensity wildfire (Kenow) impinged upon the Waterton town site in Waterton Lakes National Park, Alberta, Canada. A fuel management zone, supported by sprinkler lines and structural suppression resources effectively prevented impacts to the values at risk in the community. The plan to protect Waterton Lakes from this inevitable scenario began 33 years ago when the Park managers first identified the risk; then planned and implemented a wildfire mitigation strategy. Various fuel management treatments and a maintenance program has occurred over the past 25 years.
The Kenow Wildfire was burning 25 km away, upwind from the town site. It was uncontained, in continuous drought stricken fuels. A defense plan was activated when the fire behavior forecast put the town site in the path of a blow-up fire, predicted to spread at a rate of 100 m/min and an intensity >100,000 kw/m. The public, along with all non-essential fire personnel were evacuated. The fire arrived in Waterton town site at 10:00 pm, and burned up against the wildland/urban interface for most of the night. When daylight arrived, only two structures were lost behind the fuel break, the plan worked. Reduced fire behavior (intensity, fire type) in the fuel break; complete extinguishment into the sprinkler lines; the defendable space behind the break/sprinkler lines; and ability of suppression resources to safely and effectively suppress spot fires from embers, all worked together to provide a successful outcome. This presentation is an experience based case study that follows the continuum from risk identification through to the ultimate test of fuel break effectiveness.

Keywords: wildland/urban interface, fuel break, fuel management

Bio: Stephen Cornelsen is presently the acting Resource Conservation Manager at Riding Mountain National Park, Manitoba. He has been with Parks Canada for 30 years, primarily in a Fire Management Officer role, in a number of National Parks in Western Canada. As a long standing member on the Park Canada's National IMT, he has had the opportunity to work and travel all over Canada in various fire management positions. His area of expertise is in prescribed fire planning and implementation, having conducted upwards of 75 prescribed burns in National Parks.

013. A planning strategy to obtain net gain to the public benefit; alleviating time scarcity in fire management decisions
Presenter: Philip Bowden, Fire/Fuels Management Planner (retired USDA Forest Service),
Additional Author(s):

This presentation will draw mainly from wildfire risk application concepts in Thompson, et al [Forests, 2016, 7, 64] and from the experiences of Phil Bowden as the initial Long-Term Fire Behavior Analyst (LTAN) on last year's Chetco Bar Fire in Oregon. The presentation will explore a general strategy of using risk-informed landscape pre-planning that could have aided in alleviating time scarcity for decision makers and responders, potentially leading to net public benefit for the Chetco Bar Fire and other wildfires.
This Landscape pre-planning should provide the follow four items well in advance of any fire ignition. In the case of Chetco Bar, this type pre-planning could have made it easier to problem-solve (e.g.

containing the fire by actions such as burning out) while conditions were possibly more conducive to a net-benefit fire outcome.

• Potential wildland fire Operational Delineations (PODs)
o Where you can take long term containment actions
 Designated by experienced local fire managers
 Lessening time scarcity by doing before the fire starts.
• Spatial Objectives categories tied to each POD
o Why you are doing something
o In Land Management Plan – "contract with public"
• Spatial Requirements
o Constraints, rules of the road
 laws, Land Management Plans and regulations
• Pre-Incident Information for Decision Support
o Provide information for each POD
 POD description fire management resource needs
o Risk metrics and potential fire growth probabilities by time of season
o Previously identified POD weather windows
 Opportunities to contain fire in a given POD while achieving favorable outcomes that meet land management plan objectives.

This planning information goes well beyond firefighting preparedness and focuses on land and risk management planning; it addresses the 2009 Guidance for Implementation of Federal Wildland Fire Management Policy's foundational concept of sound risk management for all fire management activities. Risks and uncertainties relating to fire management activities must be understood, analyzed, communicated, and managed as they relate to the cost of either doing or not doing an activity. Net gains to the public benefit will be an important component of decisions.

Keywords: Net Gain, Chetco Bar, PODs, Wildfire Risk Assessments

Bio: Philip Bowden grew up in the lake states and attended Michigan Technological University from 1975 to 1979 where he graduated with a BS in Forestry. After college he spent most summers working in the west for the USDA Forest Service as temporary Forestry Technician until 1989 where he got a permanent position on the Boise National Forest. Phil worked in timber sale preparation, timber sale administration and was a Fire Management Officer for 10 years on the White River National Forest. Phil's last job was fuels planner for Region 5 (California) of the Forest Service, he is now retired.

014. The European Wildfire Risk Node: towards uniting formal and informal networks on wildfire risk

Presenter: Nuria Prat-Guitart, International Projects, Pau Costa Foundation
Additional Author(s): Vendrell, Jordi, Pau Costa Foundation
Vilalta, Oriol, Pau Costa Foundation
Borras, Mariona, Pau Costa Foundation
Ballart, Helena, Pau Costa Foundation
Plana, Eduard, Forest Science and Technology Center of Catalonia
Held, Alexander, European forest Institute, Resilience Program

Wildfire communities in Europe and around the world are established based on certain topics of interest, for example regions with similar fire regimes, but often influenced by organisational, social, cultural (notably language) and geographical factors. Several communication challenges and knowledge-sharing barriers exist between those communities arising from their different nature. As a result, the flux of information among communities is hindered. In the present climate change context and the subsequent threats of shifting the fire regimes, there is the need to bring together the current knowledge on wildfire and continue to face the present and forthcoming challenges together.

The initiative of the European Wildfire Risk Node (EWRN) has the purpose to establish links between the existing formal and informal networks, individual practitioners and communities that own the expert knowledge on wildfire risk. The node aims at acting pro-actively to shift the paradigm from response and reaction to proactive risk management across the networks, and provide services and experiences that benefit the communities. The initial steps of designing and defining the strategic lines of work of the EWRN will be presented, as well as the services, actions and experiences foreseen.

The concept idea of the EWRN is currently using Europe as a prototype to bond the knowledge transfer between wildfire communities, however this initiative can be scaled up and replicated to other world regions.

Keywords: comunities, forest fire, fire risk, Europe, knowledge exchange, communication, practitioners

Bio: Researcher and international projects manager at the Pau Costa Foundation. PhD in Peat fire behaviour and ecology.

015. Developing a Fire Danger Operating Plan for North Carolina from a State Fire Agency Perspective.

Presenter: Meyer "Cabe" Speary, Fire Environment Forester, North Carolina Forest Service
Additional Author(s):

A Fire Danger Operating Plan (FDOP) is an integral component of local fire management planning. It documents the analysis process and development of decision points to be used for future weather and fire occurrence situations, based on analysis of local conditions, historic weather, and historic fire occurrence. The decision points can be used to set levels of staffing, preparedness, and restrictions, as well as inform the public of daily fire danger. It can be used to support requests for "severity funding" to add more personnel and/or equipment, as well as bolster prevention programs, at times of elevated fire danger.

Every federal field-level agency with a fire program should be covered by a written FDOP. They are not required for state agencies. However, as the largest wildland fire agency in North Carolina, with jurisdiction over approximately 93% of the state's land, the North Carolina Forest Service is preparing an FDOP covering the entire state. The development process to date is discussed, including some of the unique challenges, such as potential for fires year around, highly variable local conditions (fuels, climate, topography) across the state, and policy mandates that differ from federal agencies.

Keywords: fire danger operating plan, staffing, preparedness

Bio: Cabe has 28 years of experience in forestry and fire management in state government, academia, and private consulting. In his current position with the NC Forest Service, he develops policy, products and training for field personnel related to fire weather, fire danger, fire behavior, forest fuels, and smoke management. Previously, he served as Assistant District Forester for the NE corner of NC where he was manager of the district's forest management program, as well as serving as a Type 3 Plans Section Chief. He holds a Master of Forestry degree from Duke University.

016. Will You Miss Me When I'm Gone? A future Without JFSP...

Presenter: Tom Zimmerman, Past President IAWF, Retired (Former Wildland Fire Management RD&A Program Manager),
Additional Author(s): John Cissel – Retired (Former JFSP Program Director)

In the Federal Fiscal Year 1998 Appropriation for Interior and Related Agencies, Congress established funding and direction to initiate the Joint Fire Science Program (JFSP). Federal wildland fire management agencies developed a plan, the Joint Fire Science Plan, to address direction and guide this program. Since its inception, JFSP has been a highly successful and integral component of the interagency wildland fire management program. It has been a leader in identifying research questions, funding studies, providing a scientific basis for planning, implementing, and evaluating fire management activities, increasing access to available information, providing a knowledge base for managers, developing tools for managers, and leading exchange and application of research results. A review of JFSP accomplishments to date shows an impressive record of achievement and speaks volumes to the success of this program. With a relatively limited budget, it has improved efficacy and accountability of agency activities by funding research on timely and important topics. No other program has directly affected so many areas of wildland fire management so positively and no other program offers researchers the opportunity to address fire management challenges in direct response to manager priorities. But, as JFSP enters its 21st year, current trends are placing its future at risk. The Federal Fiscal Year 2019 President's Budget provides no funding for JFSP. With wildland fire presenting greater challenges to natural resources and society each year, it seems incomprehensible to de-fund indispensable programs like this that advance overall management capabilities.
This presentation highlights the unique values and importance of the program, and illustrates the magnitude of impacts that will result from the loss of JFSP. These losses are significant and wide-ranging, and will not be made up by Federal agencies individually, or collectively. In addition, ending this program is not consistent with statements in Agency and Department Strategic Plans, National Program Policy, and the National Cohesive Wildland Fire Management Strategy principles that promotr basing fire management plans, activities, and decisions on the best available science, knowledge, and experience.

Keywords:

Bio: Tom has worked at multiple federal land management agencies, including the Bureau of Land Management, National Park Service, and US Forest Service. His permanent assignments include positions as Forester, Fire Control Officer, Fire Management Officer, State Fire Management Planning Specialist, Regional Fire Management Officer, Fire Technology Specialist, Fire Science and Ecological Applications Program Leader, Regional Director of Fire and Aviation Management, and Wildland Fire Management RD&A Program Manager. Tom has conducted training in the United States, China, Canada, and India, and presented papers, either in person or virtually, at conferences in the United States, Canada, Italy, South Africa, and Cyprus. Wildland fire and emergency response constituted a major focus area and Tom has over 30 years of involvement in incident management team operations including service as an Incident Commander and Area Commander on wildland fire incidents and all hazard emergency responses across the country.

019. Adaptive silviculture for climate change: Preparing dry mixed conifer forests for a more frequent fire regime

Presenter: Michael Battaglia, Research Forester, USFS Rocky Mountain Research Station
Additional Author(s): Asherin, Lance, Forester, USFS Rocky Mountain Research Station
Nagel, Linda, PhD, Colorado State University

Forest managers need robust examples of integrating climate change adaptation into silvicultural planning and on-the-ground actions. To address this need, a long-term silvicultural trail was established in a dry mixed conifer forest on the San Juan National Forest to evaluate various management options designed to enable forests to respond to a changing climate. Climate in this area is expected to get warmer with longer growing seasons, longer fire seasons, and cycles of drought conditions. Furthermore, much of the dry mixed conifer forest structure is outside its historical range of variability due to fire exclusion, grazing, and harvesting. These activities have resulted in dense forests that contain an excessive amount of white fir compared to historical densities when fire helped regulate forest structure. Three adaptation treatments were developed to demonstrate a gradient of accommodating change: Resistance, Resilience, and Transition. Each of the treatments focused on reducing forest density and manipulating species composition and spatial structure to increase resiliency to fire. In this presentation, we use the Fire and Fuels extension to the Forest Vegetation Simulator to examine the impacts of these structural changes on tree mortality and potential fire behavior.

Keywords: silviculture, climate change adaptations, dry mixed conifer

Bio: Mike Battaglia is a research forester with the USFS Rocky Mountain Research Station in Fort Collins, CO. Over the past 17 years, Mike has studied the impacts of wildfires, insect outbreaks, and harvesting on forested ecosystems throughout Colorado and the interior West. Much of his current research focuses on how forests recover after these disturbances as well as how to prepare our forests for an uncertain future climate.

020. Advancing fuel modeling and fuel treatment analysis capabilities with STANDFIRE

Presenter: Russell Parsons, Research Ecologist, USFS RMRS Fire Sciences Lab
Additional Author(s): Pimont, Francois, Research Engineer, National Institute of Agricultural Research (INRA- France)
Wells, Lucas, Ph.D. Candidate, Oregon State University
Cohn, Greg, Faculty Research Assistant, Oregon State University
Jolly, W. Matt, Research Ecologist, USFS Fire Sciences Lab
deColigny, Francois, Computer Scientist, National Institute of Agricultural Research (INRA - France)
Rigolot, Eric, Director, Mediterranean Forest Research Program, INRA – France

Managers often consider fuel treatments, such as thinning, as proactive actions that can alter fire behavior, reduce fire severity, and restore resilient ecosystems. In recent years, better understanding of the importance of spatial heterogeneity in resilience has spurred an interest in treatments that alter forest spatial patterns. To evaluate the effectiveness of such approaches requires quantifying fuel changes and how they translate to changes in fire behavior over time. As these relationships are

dynamic and often interrelated in complex ways, modeling-based evaluation efforts play a key role in such analyses. However, while commonly used forest models such as FFE-FVS offer many capabilities for modeling fuel changes, non-spatial calculations limit representation of spatial aspects of treatments, and the simplicity of underlying fire calculations further constrains analysis. Unable to accommodate the complexity and heterogeneity of real fuels, tree stands of diverse structure and composition must instead be represented with stand level averages. While these simplifications make calculations quick, they force many real world fuel treatments through an analytical bottleneck that limits their applicability. Here, we describe STANDFIRE, a prototype platform for modeling wildland fuels and fire behavior at stand scales. STANDFIRE leverages the modular architecture of CAPSIS, a forestry modeling system developed in France, providing diverse capabilities to represent wildland fuels in 3D. STANDFIRE extends the capabilities of FFE-FVS to develop spatially explicit fuel inputs to two 3D physics-based fire models, providing a more detailed alternative for analysis of how forest structure and composition may affect fire behavior and effects. We provide an overview of the system and describe its evolving capabilities. Using forest data from three sites in Montana, we explore effects of thinning on fire behavior and fire effects and compare STANDFIRE and FFE-FVS model outputs. The study demonstrates new capabilities in assessing fire behavior and fire effects changes from thinning. While both models showed some increases in fire behavior relating to higher winds within the stand following thinning, results were quite different in terms of tree mortality, with lower mortality rates, and a more pronounced reduction in mortality from thinning in STANDFIRE than in FFE-FVS. These different outcomes illustrate the need for continuing refinement of decision support tools for forest management. This system enables researchers and managers to use measured forest fuel data in dynamic, 3D fire simulations, improving capabilities for quantitative assessment of fuel treatments, and facilitating further refinement in physics-based fire modeling.

Keywords: fuel treatments, effectiveness, modeling, 3D, physics-based fire model

Bio: Russ Parsons is a Research Ecologist with the U.S. Forest Service's Fire Sciences Laboratory in Missoula, MT. Russ received degrees in Forestry from U.C. Berkeley in 1992 (B.S), the University of Idaho in 1999 (M.S.), and the University of Montana in 2007 (Ph.D.) His research focuses on simulation modeling at multiple time and space scales, ranging from landscapes and fire regimes to highly detailed 3-D fuel modeling at stand scales. A key theme of his work is to improve our understanding of how fuel changes alter fire behavior and the consequences of these changes for fire ecology and management.

021. INTERAGENCY FUELS TREATMENT DECISION SUPPORT SYSTEM: FACILITATING FUELS PLANNING FOR ALL

Presenter: Caroline Noble, Fire Application Specialist, Wildland Fire Management RD&A, USFS
Additional Author(s): Ernstrom, Kim DOI WFMRDA
Schueller, Bre USFS WFMRDA

The Interagency Fuels Treatment Decision Support System (IFTDSS) is a web-based application designed to make fuels treatment planning and analysis more efficient and effective. IFTDSS provides access to data and models through one simple user interface. It is available to all interested users, regardless of agency or organizational affiliation.
IFTDSS is designed to address the planning needs of users with a variety of skills, backgrounds, and needs. A simple and intuitive interface provides the ability to model fire behavior across an area of interest under a variety of weather conditions and easily generate downloadable maps, graphs, and tables of model results. Additionally, the application provides a step by step process for testing a

variety of fuels treatment impacts (thin, clear cut, prescribed burn) on fire behavior and comparing results to determine which modeled treatment best achieves desired results in terms of reduced fire behavior potential. It can be used at a variety of scales from local to landscape level.
IFTDSS hosts a complete set of reference data available for the entire US including LANDFIRE fuels information, SILVIS Wildland Urban Interface, Agency Ownership, as well as a modern map interface allowing users to create or upload their own data.
This presentation will give attendees an overview of the system using examples from projects being conducted by field users

Keywords: Fuels Management, planning, modeling, fire behavior, data, decision support

Bio: Caroline Noble
Fire Management Specialist
USFS – Wildland Fire Management Research, Development, and Application
Caroline has a long career of federal service beginning in 1984 spanning several National Forests and Parks in the northern Rocky Mountains and the southeast United States. She has experience in all facets and in all levels of Fire Management organizations and has held positions Hotshot, Fuels Specialist, Fire Ecologist/Planner, and Fire Management Officer. Caroline currently serves as the USFS Technical Lead for the development of the Interagency Fuels Treatment Decision Support System Application (IFTDSS).

022. A retrospective analysis of fuel treatment effectiveness following the 2014 Carlton Complex Fire in semi-arid forests of north-central Washington State

Presenter: Susan Prichard, Research Scientist, University of Washington
Additional Author(s): Povak, Nicholas, Research Ecologist, US Forest Service Pacific Southwest Research Station
Kennedy, Maureen, Assistant Professor, University of Washington Tacoma
Peterson, Dave W., Research Forester, US Forest Service Pacific Northwest Research Station

The 2014 Carlton Complex was the largest single wildfire event in Washington state history, and much of the >100,000 ha area burned under extreme weather conditions with explosive fire growth. Under a warming climate with longer fire seasons, extreme wildfire events are becoming more common in semi-arid landscapes of the western United States and have the potential to accelerate vegetation responses to climate change. Because the Carlton Complex burned over many recent fuel treatments, it offered an opportunity to evaluate if and how fuel treatments mitigated fire severity in this extreme wildfire event. As part of a larger field-based study of burn severity and post-fire vegetation recovery, we evaluated landscape patterns of burn severity using past fuel treatment records and burn severity imagery. We compared simultaneous autoregression and random forest approaches to model drivers of burn severity. Predictor layers included fuel treatment type and time since treatment, topographic indices, LANDFIRE vegetation and fuels layers, and weather summarized by progression interval. A total of 170 composite burn index plots were used to validate imagery. Under the extreme fire weather and behavior of early fire progressions, fuel treatments were put to the ultimate test and had much higher tree mortality, on average, than later fire progressions which burned under milder fire weather. Treatment type and time since treatment were important explanatory factors in fire effects but had much weaker effects on extreme fire weather days during early progression intervals. The proportion of moderate and high severity pixels, representing stand replacement in forested areas, are much higher across all treatment types in the early progression dates than later progression dates. Treatments that included underburning

were generally more effective at mitigating fire severity than those that did not (Salv and Thin only). Thin and pile burned units had high mortality in the early progressions but relatively low mortality in later progressions. Although time since fire (including prescribed fires and past wildfires) did not substantially lower model AIC and was not included in the final selected models, there is a clear trend in unit-level burn severity and time since past wildfire. Percent of stand replacement fires are significantly higher in older burned areas than more recently burned areas.

Keywords: fuel treatments, prescribed burns, burn severity, climate change

Bio: Susan Prichard is a research scientist at the School of Environmental and Forest Sciences and studies fire ecology and dry forest management issues. Her main interests are in the effects of fire and other disturbances on forest dynamics, climatic change on forest ecosystems, and fuel treatment options to mitigate wildfire effects. Her current research projects include an evaluation of past-fire burn mosaics on fire management strategies, landscape restoration, smoke and fuels management tradeoffs analyses, post-fire burn severity assessments following large fires in north-central Washington, and fuel characterization.

023. Radial Thinning to Retain Legacy Trees: Effects on Tree Growth and Fire Behavior

Presenter: Sharon Hood, Research Ecologist, USDA Forest Service, RMRS, Missoula Fire Lab
Additional Author(s): Parsons, Russell, Research Ecologist, US Forest Service
Metlen, Kerry, Forest Ecologist, The Nature Conservancy
Grayson, Lindsay, Biological Science Technician, US Forest Service
Cluck, Daniel, Entomologist, Forest Health Protection, US Forest Service
Jones, Bobette, Ecologist, Todd Sloat Biological Consulting, Inc.

Restoration efforts to improve vigor of large, old trees and decrease risk to high-intensity wildland fire and drought-mediated insect mortality often include reductions in stand density. These restoration and fuel treatment objectives can conflict with regulatory and social constraints, especially in areas with species of conservation concern. Radial thinning is an increasingly popular treatment designed to reduce mortality and improve vigor of old legacy trees while limiting stand-level effects. We present results of two radial thinning studies examining 15-year growth response and potential fire behavior. The first study examined old ponderosa pine (Pinus ponderosa) and Jeffrey pine (Pinus jeffreyi) trees in northeastern California, US subject to two levels of thinning treatments compared to an untreated (control) area. Density reductions involved radial thinning (thinning 9.1 m around individual trees) and stand thinning. Annual tree growth in the stand thinning increased immediately following treatment and was sustained over the 15 years. In contrast, radial thinning did not increase growth, but slowed decline compared to control trees. Importantly, focusing stand density reductions around the immediate neighborhood of legacy trees was insufficient to elicit a growth response, calling into question treatments attempting to increase vigor of legacy trees while still maintaining closed canopies in dry, coniferous forest types. The second study used the Wildland-Urban Interface Fire Dynamics Simulator (WFDS) to model potential fire behavior and lethal temperature profiles in radially-thinned conifer stands in southwestern Oregon, US where recent broadcast underburns in radially-thinned stands caused unanticipated high levels of crown scorch in legacy trees. This observation prompted further investigation into a possible “chimney effect” of concentrated heat venting through radially-thinned patches when underburning otherwise dense stands. We report the combined effects of radial thinning patch size and stand density on fire behavior and predicted legacy tree crown scorch. We hypothesized that thinning to lower matrix stand densities or widening the treated patch size around legacy trees will ameliorate

the "chimney" effect when broadcast underburning radially-thinned stands. Combined, these studies provide managers with information about the appropriateness of radial thinning as a means to retain large, old legacy trees on the landscape.

Keywords: fuel treatment, fire behavior, treatment effectiveness, old-growth

Bio: Sharon Hood is a Research Ecologist with the US Forest Service, Rocky Mountain Research Station at the Fire Sciences Laboratory in Missoula, MT. She studies the impact and role of fire in forested ecosystems and focuses primarily on fire-caused tree mortality and fire-bark beetle interactions. Sharon earned a PhD in Organismal Biology and Ecology from the University of Montana, a MS in Forestry from Virginia Tech, and a BS in Forestry from Mississippi State University. https://www.firelab.org/profile/hood-sharon

024. Stand-level dynamics of pinyon-juniper woodlands following hazardous fuels reduction treatments in Arizona

Presenter: David Huffman, Director of Research and Development, Northern Arizona University
Additional Author(s): Stoddard, Michael, Senior Research Specialist, Ecological Restoration Institute, Northern Arizona University
Crouse, Joseph, Senior Application Systems Analyst, Ecological Restoration Institute, Northern Arizona University
Springer, Judith, Senior Research Specialist, Ecological Restoration Institute, Northern Arizona University

The pinyon-juniper biome is one of the most common forest types in the western United States, and these woodlands form the matrix of many wildland-urban interface areas. Relatively few studies have examined stand-level responses of pinyon-juniper woodlands to hazardous fuels reduction treatments, although tree thinning and prescribed fire may lead to long-term changes in overstory composition and structure, and understory diversity. To investigate differential effects of silvicultural prescriptions commonly used for hazardous fuels reduction, we established a completely randomized block experiment in Pinus edulis (Colorado pinyon pine) - Juniperus osteosperma (Utah juniper) woodlands of northern Arizona. We monitored overstory tree growth and mortality, tree regeneration and ingrowth, and understory vegetation changes in untreated units (Control) as well as units receiving prescribed fire (Burn), thinning (Thin), and combined treatments (Thin + Burn). Results showed that post-treatment (2007-2017) basal area increment was highest in Thin + Burn treatments for both pinyon pine and juniper trees. However, pinyon pine mortality was significantly higher in the Thin + Burn treatment (26.2%) compared with Control, Burn, and Thin treatments (4.3 - 9.1%). Juniper mortality was not affected by treatment (2.1 - 13.5%). Regeneration density was not affected by treatment but appeared to maintain stable size class distributions while fluctuating with climate. Over the 2007-2017 period, ingrowth of trees into the overstory (> 1.37 m height) resulted in net positive increases in both pinyon pine and juniper stand density in the Thin treatment, whereas only juniper density increased in Thin + Burn. Overstory density of both species decreased in Control and Burn treatments. Total understory cover was significantly higher in Thin and Thin + Burn compared with Control and Burn treatments, and these differences were driven by increases in cover of grasses and shrubs. Although understory species richness tended to be higher in Thin and Thin + Burn than Control and Burn treatments, richness was not significantly affected by treatment. Results from this study suggest treatment-influenced transitions toward alternative structural states and have implications for long-term fuels management.

Keywords: Southwest; fuels management; monitoring; structural states; pinyon-juniper

Bio: Dr. Huffman is Director of Research and Development with the Ecological Restoration Institute at Northern Arizona University. His interests include forest restoration ecology, fire and fuels management, and plant population ecology.

025. Chemical Evaluation of Wildland Firefighting Gear

Presenter: Crystal Forester, Research Chemist, Evaluation and Testing Branch, National Personal Protective Technology Laboratory, National Institute of Occupational Safety and Health
Additional Author(s): Tarley, Jay, Physical Scientist, Evaluation and Testing Branch, National Personal Protective Technology Laboratory, National Institute of Occupational Safety and Health

Wildland fire fighting gear differs from structural firefighter turnout gear in that it does not contain the array of coatings and flame retardants found on structural gear. While structural turnout gear is comprised of three layers: an outer layer, moisture barrier, and a thermal liner, wildland firefighting gear is a single layer that may be worn in direct contact with skin. The gear is worn daily for up to three weeks without laundering. The gear is typically not segregated from living areas while in use or before laundering. Most laundering takes place at the end of a fire incident and is conducted in a household washing machine.

During the course of wear, the gear may be exposed to a myriad of chemicals from fires. In this study chemical contamination was determined and then laundry methods were compared to determine if current procedures adequately remove the chemical contamination.

In the work presented here, field soiled gear was cut into swatches and the contaminants extracted using a laboratory method sufficient for removal of multiple classes of chemicals including carcinogens such as poly-nuclear aromatic hydrocarbons, phthalates and phenolics. While not all chemicals on the gear were carcinogenic, they may present other health concerns. The extracted samples were analyzed using gas-chromatography/mass spectrometry for a qualitative determination of chemical contamination. Several classes of compounds were found on the soiled gear including carboxylic acids, aldehydes, alkanes, alkenes, phthalates and complex molecules such as cholesterol. There is no definitive way to determine the cause of the contamination found on these garments.

Additional swatches of the soiled gear were attached to cotton bath towels and placed in a household machine with additional towels added for weight and stability, then laundered using a commercial detergent. Remaining chemicals on these swatches were also extracted and analyzed and the results were compared to those from the field soiled gear to determine if this method of laundering sufficiently removes contaminants. To further investigate laundry efficiency, additional soiled swatches from the same garment were attached to cotton towels and laundered in a Milnor Extractor using detergent specifically designed for firefighter garments and analyzed as previously described.

A review of qualitative data showing chemicals remaining on the swatches following laundering in a household machine compared to those found after laundering in a commercial extractor showed few differences in contaminant removal. Further quantitative studies will be performed to validate these findings.

Keywords: chemical contamination, decontamination, laundry

Bio: Mrs. Forester received her Bachelor of Arts degree with a major in Chemistry from West Virginia University in 1991 and began working as a bench chemist in an environmental water and soils testing laboratory. In 2001 she began her career at NIOSH in the Health Effects Laboratory Division and authored several publications on gas-phase chemistry in indoor environments. She returned to WVU and received her Master of Science in chemistry in 2013 and is currently working in the National Personal Protective Technology Laboratory investigating surface chemistry and off-gassing from firefighter clothing.

026. Team Awareness Kit, enhancing firefighter safety through better situational awareness

Presenter: David Zader, Wildland Fire Administrator, City of Boulder Fire Department
Additional Author(s): Zader, David, Wildland Fire Administrator, City of Boulder Fire Department-Wildland Division
David Tally, Director of Applied Technologies, PAR Goverment

Situational awareness during wildland fires is complicated and critical to firefighter safety. In recent years a military situational awareness application once called ATAK (Android Tactical Assault Kit) has gone through a technology transfer from the military to use by public safety. Now call the Team Awareness Kit (TAK) this capability is an operator focused, mission ready, mature and proven situational awareness application.

TAK is an open source, US government owned application that has been in continuous development and use for nearly 10 years with US special operations forces. Recently TAK has been in use by multiple federal law enforcement agencies and was deployed widely during the 2017 hurricane season to all types of public safety teams.

TAK is a GPS enabled mapping and visual communications application that brings high resolution situational awareness to all users on a network. TAK is agnostic to IP data networks and data types which simplifies sharing of graphical imaging data. The application brings together a variety of very powerful tools that can be used in a server-client relationship with cellular based networks, or directly peer to peer using mobile ad-hoc mesh network radios or wifi for use in more remote areas of operation. Using state-of-the-art cloud based technology enables connectivity to users around the world.

Features of TAK include real time tracking of resources, 2d and 3d collaborative mapping with unlimited imagery options and navigational tools and augmented reality for all methods of travel, including specialized symbology for point marking, multiple drawing tools, direct kml and shp file import. TAK is designed to ingest various sources of open data streams such as live weather, crowd sourced maps, and live air traffic.

The TAK application plugin architecture allows for a wide range of specialized tools including airspace management, scaled mission planning, visualized elevation data, real time line of sight analysis, UAV control, geo-referenced video downlink, and casualty evacuation coordination. Because of the open source architecture TAK is under continuous development and unlimited specialized plugin tools can be developed in the future. TAK currently operates on Android mobile devices and tablets as well as Windows operating systems, with an iOS version planned for release in the future.

This presentation will demonstrate the basic functionality of TAK, methods of data transmission to field going personnel and use cases of the application.

Keywords: Mobile Ad-hoc Mesh Network, Situational Awarness, ATAK, WINTAK, ITAK, TAK, Firefighter Safety

Bio: Dave Zader has been the Wildland Fire Administrator for the last 12 years at the City of Boulder Fire Department. Dave started his career in Prince William County Virginia and has worked at the USFS, NPS and three municipal fire departments. Dave works on local and national incident management teams as a HEB2 and DIVS, Dave teaches courses nationally and has served in many operational and incident management roles on incidents such as hurricane Sandy, Colorado floods, and fires across the US. Dave has a bachelor of science in Forestry and Wildlife Management from Virginia Tech.

027. Pocket Wildfire Analyst

Presenter: Monedero Santiago, Main Scientist, Technosylva
Additional Author(s): Joaquin Ramirez, PhD, Principal, Technosylva
Adrian Cardil, PhD, Fire Behavior Researcher, Tecnosylva

We present a mobile application built for Android and IOS aimed to be used by the firefighter community to help evaluate the expected fire progression in an incident as well as the risk associated to it in a user-friendly way. The core of the application is inspired in the well-known software Behave++ as it shows punctual fire characteristics based on user introduced environmental inputs (wind, moisture, air temperature, etc) and also supports 2D graph outputs between different variables. The mathematical models implemented are all widely used and in most cases are the ones used software like Behave++, Farsite or Flammap. The application has integrated GIS capabilities, can work online and offline, retrieves fuel and canopy data from Landfire as well as weather data from close by weather stations using the third party API Synoptic (these both feature only available in the US). The modules implemented include crown and surface fire behavior, residence time, scorch height, fire charts, safe separation distance, and ignition probability.

Keywords: behave, mobile, modeling

Bio: Santiago holds a bachelor's degree in Physics and a European awarded PhD in Applied Mathematics, has several publications in specialized engineering journals, and is the scientific leader and principal R&D investigator for wildfire modeling related projects in Tecnosylva, being the lead researcher at the Wildfire Analyst™ modeling framework.
Multidisciplinary profile with international R&D and engineering management experience. Bilingual Spanish-English with high level of Mandarin Chinese and French

028. Fireline medical: Solutions for the future

Presenter: Ray Storm, Adventure Medics
Additional Author(s):

Addressing current Fireline medic standards, practices, protocols, and certifications we will define what is effective medical care, proper training, and innovations in equipment and patient extrications. We will discuss the future of fireline medicine and how we can move forward to insure line medics are properly prepared and trained to use their full scope of practice under adverse fire conditions, difficult terrain, and with limited resources. This presentation will also explore the financial cost of line medics and how to "get the biggest bang for the buck" when ordering line medical resources.

Keywords:

Bio: Ray Storm has an extensive knowledge in backcountry medicine, structure firefighting/EMS, and wildland fire. He currently manages the wildland division of Adventure Medics and has been developing a "best practices" approach to fire line medicine for Adventure Medics. He saw a greater need for better standards, protocols, and training for wildland fire EMS personnel and strives to share this knowledge with the wildland fire community. His goal is to bring better training and knowledge to fire line EMS personnel, Incident command teams, and firefighters for more efficient patient care and firefighter safety.

031. Peatland Fires: Field Reference Conditions – Challenges and Research Needs

Presenter: Kevin Ryan, Senior Scientist, FireTree Wildland Fire Sciences, LLC
Additional Author(s): Grahame Applegate Associate Professor Tropical Forests and People Research Centre, University of the Sunshine Coast, QLD, Australia
Laura L. B. Graham, PhD Research Ecologist, Project Leader; Borneo Orangutan Survival Foundation Kantor BOSF-Mawas Jl. Nuri No.9 Palangka Raya 73112 Kalimantan Tengah, Indonesia
Thomas Andri Field Team Leader Borneo Orangutan Survival Foundation Kantor BOSF-Mawas Jl. Nuri No.9 Palangka Raya 73112 Kalimantan Tengah, Indonesia
Mark A. Cochrane, PhD Professor Appalachian Laboratory University of Maryland Center for Environmental Science (UMCES) Frostburg, MD 21532 USA

Fire has long been used in swidden agriculture in tropical forests. Increasingly it is being used to convert tropical forest to agri-business at family farm to corporate spatial scales. When these conversions occur in peatland forests massive fluxes of greenhouse gasses (GHG) can occur if surface fires become established in peat soils. Surface fires, flaming combustion in living and dead above-ground biomass, is responsible for the aerial extent of fires and substantial atmospheric emissions. However, the amount and chemistry of GHG are substantially determined by the depth of burn into organic soils (peat). Whether or not sustained smoldering combustion establishes in organic soils depends primarily on the peat's near-surface moisture content. The depth of burn depends on the peat's depth and its moisture profile above the water table, which vary seasonally with the hydro period, with longer-term weather cycles (e.g., ENSO) and distance to drainage sources of natural or human origin, i.e., rivers and canals, respectively. The extent to which other bulk properties (e.g., peat parent material, density, degree of decomposition [fibric, hemic, sapric], heat content, etc.) affect combustion is uncertain. Emissions of GHG depend on the depth of burn and the bulk properties of the peat burned, both of which vary spatially and temporally. Depth varies with undulations of the mineral soil substrate and typically increases with distance from natural waterways. Canal building introduces major new sources of variation affecting both the frequency of ignitions and depth of burn. Among the temporal variations that are poorly understood are changes that occur with successive fires and accelerated heterotrophic decomposition following deforestation and drainage.

As part of a study to refine GHG emissions for Intergovernmental Panel on Climate Change (IPCC) carbon accounting extensive fieldwork was conducted to improve estimates obtained from satellite-based observations of the aerial and temporal extent of fires in Central Kalimantan, Indonesia on the island of Borneo. We present and critique field methods developed to document conditions affecting the spread of peatland fires and their depth of burn. These are discussed in the context of IPCC Tiern carbon accounting guidelines. We identify potential sources of error and observations on how

improved methods might reduce said errors. We identify three major challenges to improving field reference data associated with remote sensing of peatland fires: social-political-cultural constraints affecting workability, operational-logistical realities, and limited biophysical-ecosystem science in dramatically altered, rapidly changing peatlands. Research needs are identified.

Keywords: Peatland fire ecology, greenhouse gas emissions, sampling methods

Bio: Kevin is a senior scientist and environmental consultant with broad experience in the role and use of fire in upland and peatland ecosystems. He participates in restoration and climate-related research and advises policy makers and managers on fire-environmental issues.

032. Mapping the impact of Canadian boreal forest canopy interception on satellite detection of smouldering wildfires

Presenter: Joshua Johnston, Forest Fire Research Scientist, Canadian Forest Service
Additional Author(s): Wooster, Martin, Professor of Earth Observation, King's College London, NERC NCEO
Brookes, Alison, Research Support Officer, Canadian Forest Service
McFayden, Colin, Forest Fire Research Specialist, Aviation Forest Fire & Emergency Services, Ontario Ministry of Natural Resources & Forestry

Satellite-based "hotspot" wildfire detection has been researched many years, and more recently, considered for its support in Canadian operational fire management. However, its operational use is complicated by the notion of "detecting a hotspot" vs. "early detection" for emergency response. In Canada, the success of initial attack fire suppression is dependant on detecting small fires when they are sub-canopy smoldering incidents. Tree canopies partly obscure surface fires when viewed from space. It is not clear how large fires need to be for detection, or the required spatial resolution for confident discrimination. The suitability of this type of satellite "hotspot" for operational fire management therefore remains unclear.

To explore this, we collected laboratory thermal image measurements of high temperature calibration targets, set at smoldering fire temperatures, viewing through a series of diffuse Picea glauca canopies with varying leaf area index (LAI). The data was used to construct a simple mathematical representation for conifer canopy thermal infrared transmittance, based on effective LAI measures. This model was subsequently used in conjunction with satellite-derived global scale LAI maps to determine the sub-canopy smoldering area required to sufficiently elevate the pixel brightness temperatures of different spatial resolution remote sensing satellites beyond their active fire detection thresholds. Minimum fire detectability metrics are mapped across the Canadian boreal zone, and are discussed in the context of near real-time satellite hotspots becoming a potential response tool to support the early detection of smoldering fires in Canada and becoming a potential emergency response tool.

Keywords: hotspot, fire detection, canopy interception

Bio: Dr. Joshua Johnston came to the Canadian Forest Service after working for the Ontario Government (AFFES) for 7 years as a fire ranger. Josh holds degrees in Fine Arts and Mathematics, and a PhD from King's College London (UK) for his thesis entitled "Infrared Remote Sensing of Fire Behaviour in Canadian Wildland Forest Fuels". Currently he is a Forest Fire Research Scientist with the Canadian Forest Service. His research focuses on the development of remote sensing tools for studying the physical properties of combustion and fire behaviour, as well as the adaptation of remote sensing tools for operational fire management. He is the leader of the user and science team for the proposed Canadian Wildland Fire Monitoring Sensor airborne and satellite missions. Beginning in 2016 Josh became the Canada's lead for emergency tactical wildfire mapping, including Torchlight.

033. Role of the ornamental vegetation in the propagation of the Rognac fire 2016
Presenter: Anne Ganteaume, Research Fellow, IRSTEA
Additional Author(s):

In August 2016, a fire due to negligence during leisure activities started in the wildland-urban interface (WUI) of Rognac (a community located to the NE of Marseilles, SE France) and, driven by a strong wind and by exceptionally dry and warm climatic conditions, burned almost 3000 ha, mostly in urbanized area, in a few hours (rate of spread up to 5.3 kmh-1). These severe meteorological conditions entailed difficult firefighting operations, already hampered by a lack of resources due to several aircrafts grounded for maintenance and by six other fires burning at the same time in the area. The fire impacted six communities, ending up in the outskirt of Marseilles, some 15 km away from its ignition point.
Besides the exceptional size for a WUI fire, what mostly characterized the Rognac fire was its propagation through the WUI to the core of the urban areas, becoming more an "urban fire" than a "WUI fire". The fire propagation mainly occurred through ornamental vegetation such as the ornamental hedges located along the roads that led to buildings causing much damage. In total, 26 homes were destroyed and 155 partially damaged, often because of the poor positioning of ornamental trees or hedges (mostly big pine trees and cypress hedges) planted too close to the housing and sometimes combined with a lack of clear-cutting (however mandatory around housing located at least at 200m from forest/shrubland areas). The damage was due to strong radiant heat emitted by the burning vegetation surrounding homes as well as to the massive amount of embers generated by this vegetation.
This exceptional fire event (since 2003) underlines the need to better understand the fire propagation through WUI vegetation that differs from wildland vegetation especially by its strong heterogeneous structure and by the presence of exotic species whose fire behavior is unknown for the most part. In order to improve fire prevention in WUI, under climatic conditions more and more conducive to fire with the on-going global change, it is thus necessary to adapt the fire behavior modelling to this type of vegetation.

Keywords: Wildland-urban interface, fire propagation, ornamental vegetation

Bio: Dr Anne Ganteaume is currently a research fellow at Irstea, a French public research institute involved in environmental science and technology. She works on forest fires in the department "Mediterranean ecosystems and risks" located in Aix-en-Provence (SE France) since 2006. She received a PhD in Ecology from the University of Aix-Marseille in 1993. She is involved in several European research projects, sometimes as team leader or coordinator. Her research interests are fuel characterization, fuel flammability and combustibility, forest fire causes and fire risk assessment.

034. Fuel variability impacts fire behavior: small-scale studies utilizing drone technology

Presenter: Christopher Moran, Ph.D. Student, National Center for Landscape Fire Analysis, University of Montana
Additional Author(s): Seielstad, Carl, Professor, National Center for Landscape Fire Analysis
Queen, Lloyd, Director/Professor, National Center for Landscape Fire Analysis
Parsons, Russ, Research Ecologist, USDA Forest Service Fire Laboratory
Cunningham, Matt, M.S. Student, National Center for Landscape Fire Analysis
Wallace, Tim, Analyst, National Center for Landscape Fire Analysis
Hoff, Valentijn, Analyst, National Center for Landscape Fire Analysis

The relative influence of fuel variability on fire behavior has implications for the fire continuum from climate change effects to prescribed burning strategies to fuel treatment design and effectiveness. Emerging remote sensing technologies allow new sampling techniques to assess fuel-fire relationships from a spatially explicit perspective. Here, we use unmanned aerial vehicles (UAVs or drones) to both assess the pre-burn fuel environment and measure fire behavior on six, 100 m2 plots in a prescribed burn at Lubrecht Experimental Forest, Montana, USA. We calculate the spatial gradients of change in variables characterizing fuel structure and type and then assess their influence on changes in rate of fire spread. The presentation will focus on methods to characterize the fuel environment using new remote sensing techniques, namely structure-from-motion photogrammetry, calculation of fire behavior metrics from UAV-based thermal sensors, and preliminary findings of spatially explicit analysis correlating fuel variability to change in fire behavior. Implications for management and future planned experiments are also discussed.

Keywords: fuel, fire behavior, variability, remote sensing, drones, prescribed burning

Bio: Chris Moran is a Ph.D. student at the University of Montana-Missoula. He earned his Bachelor's degree in biology and mapped fires with satellite imagery for the USGS. Later, he assessed the effectiveness of fuel treatments burned in wildfires and measured changes in fuels due to mountain pine beetle-caused mortality while working on his Master's at South Dakota State University. From 2013 on, he has been involved in operational wildfire management and prescribed burning from Georgia to Alaska. In Missoula, he uses various remote sensing technologies, such as lidar, photogrammetry, and thermography, to assess pattern (fuel) – process (fire) relationships.

035. Homes as Fuel: Do We Need a New Fire Behavior Paradigm?

Presenter: Daniel Leavell, Assistant Professor, Forest and Fire Agent, Oregon State University
Additional Author(s):

Wildfires in the last two years have demonstrated an alarming trend – more so than before. For many reasons, i.e. weather getting warmer, drier, lower humidity and fuel loading increase – fires are burning more acres with higher intensity and severity. Where a dozen homes lost in a wildfire was an exception that happened in spite of our protection efforts, now we are seeing hundreds and thousands of homes lost. Why? My presentation will delivery some potential reasons for this and some recommendations for possible understanding, and hopefully solutions. I propose we use this threshold crossed as an opportunity to shift our fire behavior analyses, predictive models, planning efforts, strategies, and tactics. To merge structure fire ecology with wildland fire ecology – to merge structure fire management with wildland fire management in a new and more suitable paradigm applicable to various scales – from point to community to landscape. My presentation will end with some recommendations to follow through towards resolution.

Keywords: Wildland, structure, fire ecology, fire management

Bio: 2006 – 2012: Fire Chief for a 15 square mile, all-risk/all-hazard volunteer Fire Department/Fire Service Area.
1973 – 2012: Wildland firefighter for every fire season – Operations Section Chief (11 years) for Type 1 and 2 Incident Management Teams. Served as Field Observer, Structure Protection Specialist, fireline EMT, Safety Officer, Situation Unit Leader, and Plans Chief trainee concurrent with Operations experience and training. Participated on rehab BAER Teams, Agency Administrator, and other fire-related jobs. Served on wildland fires from Florida to Alaska, and all areas in between. Also participated in flood, hurricane, and disaster recovery incidents.
1973 – 2010: Worked for the Forest Service: 5 years starting with the Fire Control Lab in Riverside, CA and moved to the Forest and Range Experiment Station in Corvallis, OR. Rest of the time worked and lived in remote Ranger Stations in N. Idaho, NE Oregon, Central Idaho, and NW Montana. Silviculture certification in Region 6 in 1987 to 1992. Retired in 2010 as Vegetation Program Manager (silviculturist, forest ecologist, fire ecologist) on the Kootenai NF in NW Montana.

037. The roles of prescribed fire in reducing duff loads and subsequent wildfire emissions and air pollution

Presenter: Yongqiang Liu, Research Meteorologist, USDA Forest Service
Additional Author(s): Fengjun Zhao, Forest Scientist, Chinese Academy of Forestry
Scott Goodrick, Research Meteorologist, USDA Forest Service
Bengamin Hornsby, Forester, USDA Forest Service
Jeffrey Schardt, Fire Manager, USDA Forest Service

Prescribed fire (Rx fire) is a forest management tool to maintain forest health by reducing hazardous fuels. It also can impact subsequent wildfire occurrence, severity, and carbon emissions. This study investigated a new role of Rx fire in reducing wildfire air pollution consequence through reducing duff loads in a long-unburned oak-pine mixed forest by examining the 2016 Rough Ridge fire in the Cohutta Natural Wilderness of the southeastern United States. We compared fuels, emissions, and smoke between an experimental Rx fire site and a nearby site without Rx fire and historical wildfire over decades using a combined approach of field measurement and modeling. A major feature of the fuels is that, because the current fire management plan does not specifically allow Rx fire in the Cahutta Wilderness, a very deep duff layer was developed in the long-unburned site. It was burned mainly during the flaming rather than smoldering phase. Smoke particles, which could be lifted to high elevations due to the large heat release from flaming, were transported long-distance, causing air pollution in metro Atlanta about 150 km in south. In contrast, the duff layer in the experimental Rx fire site was only as half as deep and the burning of the duff layer would cause almost no air pollution in metro Atlanta. This difference indicates the important role of Rx fire in mitigating the air pollution consequence of future wildfire and suggests the need to rethink the no Rx fire practice in natural wilderness like the Cahutta Wilderness.

Keywords: fuel sampling, smoke modeling, PM2.5, Rough Ridge fire, natural wilderness

Bio: Dr. Yongqiang Liu is specialized in fire-ecosystem-climate interactions. The specific research areas include future wildland fire and forest fuel trends under changing climate, the climate and air quality impacts of wildfires, smoke dynamics and modeling, and the climate and hydrological impacts of afforestation. He has published over 100 research papers and conducted a number of fire and smoke research projects.

038. Quantifying avoided wildfire emissions from significant wildfires

Presenter: Thomas Buchholz, Senior Scientist, Spatial Informatics Group (SIG) LLC
Additional Author(s): David Saah, Managing principal, Spatial Informatics Group LLC
David Schmidt, Research Scientist, Spatial Informatics Group LLC
Jason Moghaddas, Research Scientist, Spatial Informatics Group LLC
Jarrett Barbuto, Research Scientist, Spatial Informatics Group LLC

The western U.S. has millions of acres of overstocked forestlands at risk of large, uncharacteristically severe or catastrophic wildfire owing to a variety of factors, including anthropogenic changes. In California, this includes early 20th century timber harvest practices followed by nearly a century of exclusion of fire as an ecosystem process, exacerbated today by periods long term drought influenced by climate change.
As market-based approaches to global climate change are being considered and implemented, one important emerging strategy for changing the economics of fuels treatments is to generate carbon emission offset credits. Carbon credits can theoretically be generated by projects that reduce potential emissions from wildfire, such as by reducing the risk of large high severity wildfires for a given portion of land. In reality, avoided emissions must be weighed alongside carbon sequestration from forest growth, emissions from treatment activities, wood product life cycles, and many other factors. Developing carbon emission offsets as an effective tool for forest and fire mangers thus requires an integrated approach that considers wildfire probabilities and expected emissions, as well as net expected carbon loss or sequestration over time.
In collaboration with California stakeholders from the private, public, and non-profit sectors, and the Colorado-based Coalition for the Upper South Platte, we present an avoided wildfire emissions accounting framework. Our framework integrates scientifically-based models for predicting changes in fire behavior and related CO_2 and non-CO_2 greenhouse gas emissions. The framework also incorporates delayed reforestation following high-severity wildfires, both with and without hazardous fuel treatments.
Our "real world" avoided wildfire emission accounting framework that is currently being tested on 650,000acres around the Eldorado National Forest in Northern California. We intend to submit this carbon offset protocol to the American Carbon Registry in 2018 for endorsement in Colorado and California.

Keywords: Wildfire emission accounting, fire and fuel modeling, life cycle assessment, carbon offsets

Bio: Dr. Thomas Buchholz leads the Forest and Agriculture Team at the Spatial Informatics Group. Thomas has over 14 years of experience in working with governments, academia, non-profits and the private sector in the management and economics of natural forests, timber plantations, and woody energy crops. His recent work includes micro- and macroeconomic analysis and carbon accounting of forest wildfires and forest based bioenergy use in the US, Europe and Sub-Saharan Africa. Thomas is an affiliate of the University of Montana and the Gund Institute for Environment at the University of Vermont.

039. Simulating Plume Rise, Dispersion and Radiative Smoke Impacts In a Coupled Fire-Atmosphere Framework

Presenter: Adam Kochanski, Research Assistant Professor, Atmospheric Sciences Department, University of Utah
Additional Author(s): Derek V. Mallia, Postdoctoral Research Associate, University of Utah
Jan Mandel, Professor, Director of the Center for Computational Mathematics, University of Colorado, Denver
She Schranz, NOAA/CIRA
Matthew Fearon, Assistant Research Scientist, Desert Research Institute
Tim Brown, Research Professor, Climatology Director of Western Region Climate Center, Desert Research Institute

Resolving the transport of smoke from wildfires in atmospheric transport and chemical models is often difficult due to deficiencies in estimating the plume injection height, which has been highlighted as a key element controlling the smoke transport. Currently, several plume rise models exist, however, their success in rendering the plume dynamics has been mixed when validated against satellite observations. It has been hypothesized that the sources of errors for these parameterizations can be attributed to uncertainties associated with fire input parameters such as the heat flux and fire area, in addition to other assumptions such as the plume geometry. One of the practical problems associated with using these models in forecasting applications is estimating the future fire intensity and fire area. Due to the lack of physical representation of the fire itself, plume rise models generally compute the future plume rise based on historical satellite fire observations, assuming that the fire activity doesn't change drastically from day to day.
In this study, we utilize the WRF-SFIRE-CHEM modeling framework, which couples an atmospheric, chemical, and fire spread model, in an effort to resolve the fire progression, plume rise and dispersion as well as the radiative impacts of smoke. This modeling framework was used to simulate wildland fires in Washington and California during the summer of 2015. Preliminary results indicate that this modeling system could be used to directly resolve plume evolution, and the coupling with the fuel moisture model results in realistic diurnal plume rise fluctuations driven by the daytime/nighttime changes in the fire activity. One of the unique aspects of this framework is that the fire smoke interacts with atmospheric radiation. Our simulations indicate that wildfire smoke may significantly reduce incoming solar radiation, and lead to significant local surface cooling (up to 2-3 degrees). Direct heating from the fire itself does not significantly enhance atmospheric stability, however mid-level warming simulated in the smoke layer suggests that absorption in this layer, accompanied by the surface cooling due to the smoke shading effect, may enhance the local inversions. This preliminary study suggests that the integration between the fire propagation, plume dynamics and radiative impacts of smoke in a coupled modeling framework such as WRF-SFIRE-CHEM not only enables dynamical simulations of the plume height but can also simulate enhanced smoke concentrations due to smoke-enhanced local inversions.

Keywords: Smoke, Inversion, WRF-SFIRE, WRF-FIRE, fire modeling

Bio: Adam Kochanski is a Research Assistant Professor at the University of Utah Atmospheric Sciences Department, working on coupled fire-atmosphere modeling. He is a co-developer of the community fire-atmosphere model WRF-SFIRE, WRF-SFIRE-CHEM and the coupled fire-atmosphere forecasting system WRFX.

041. Plume Evolution from Wildfires and Aged Regionally Distributed Smoke Sampled during BBOP

Presenter: Lawrence Kleinman, Chemist, Brookhaven National Laboratory
Additional Author(s): Sedlacek, Arthur, Brookhaven National Laboratory
Lewis, Ernie, Brookhaven National Laboratory
Springston, Stephen, Brookhaven National Laboratory
Wang, Jian, Brookhaven National Laboratory
Chand, Duli, Pacific Northwest National Laboratory
Shilling, John, Pacific Northwest National Laboratory

During the first phase of the BBOP field campaign, conducted in the Pacific Northwest, the DOE G-1 aircraft was used to follow the time evolution of smoke from wildland fires from near the point of emission until the plumes had aged for several hours. Older plumes were also sampled, in particular, in conjunction with surface observations at Mount Bachelor Observatory. In eight wildfire plumes, flights included multiple transects at varying downwind distances that allow us to determine the chemical and physical time evolution of trace gases and aerosols in a pseudo-Lagrangian frame that encompasses the first hours of atmospheric processing. We use the eight plume flights and measurements in more aged smoke to identify common features.

We observed a small decrease (~ 25%) in aerosol mass normalized to CO, with increasing downwind distance. There is, however, significant scatter; half of the flights show an increase and half a decrease. Light scattering, normalized to CO, increases by 75% in as little as 2 hours, with a flight to flight variation between ~ 15% and a factor of two. The mass scattering efficiency (MSE), has an average increase of more than a factor of two. The range in MSE between flights is 2 to 6. Increases in MSE with aging are expected from particle growth, as evaluated from Mie calculation that are based on multi-wavelength scattering observations and particles size measurements below 270 nm from the FIMS. An MSE of 6 is characteristic of aerosol particles with a high real refractive index, say above 1.6, but are within the range of values predicted given instrument uncertainty.

Plume age is determined from NOx/NOy which typically decreased by an order of magnitude in a few hours, reaching values lower (more aged) than background air. The ratio of toluene to benzene is nearly constant indicating that the decrease in NOx is not mostly due to OH+NO2, unless changes in toluene/benzene are obscured by the mixing-in of background air. Several fire plumes had O3 concentrations above 120 ppb. Our clearest example of rapid O3 formation occurred in an along-plume flight leg. O3, NO, NO2, and NOy increased to 180, 220, 110, and 500 ppb, respectively before concentrations dropped precipitously upwind of the fire.

Keywords: BBOP wildfire aging aerosol MSE photochemistry

Bio: My graduate studies and earliest work was in quantum chemistry. For the past 35 years, I have worked on a range of atmospheric chemistry problems, in rough order: aerosol health effects, acid rain, photochemical oxidants, and aerosols as agents of radiative forcing. I have analyzed data from many field campaigns, most recently as co-PI (with Art Sedlacek) of the DOE sponsored Biomass Burn Observation Project (BBOP)

041. The Summer of Smoke: 2017

Presenter: Peter Lahm, Air Resource Specialist, USDA, Forest Service
Additional Author(s):

The Summer of Smoke: 2017-The western wildfire season of 2017 marks a transition point in the management of wildfire. The summer of 2017 was characterized by widespread smoke from Canada and the United States impacting millions. Smoke impacts at levels and durations to warrant Congressional interest and perpetual media attention. Costs of these significant impacts that were previously occasional and fleeting are now of long duration and at levels which warranted concerns from many in the public health sector. Questions are being raised as to what decisions and actions can be undertaken to reduce this significant public health risk. What are the costs in terms of regulatory impacts to workloads of state and federal regulatory agencies seeking to avoid impacts of National Ambient Air Quality Standards exceedances by utilizing the new revisions to the Exceptional Events Rule? What were the perceived costs to public health and businesses when questions were raised such as where can I go to get out of the smoke? How were medical impacts reported and what were they as the public strived to "live with fire and smoke." Are there significant policy implications for land managers striving to promote "living with fire" which has become a mantra for some? Are all land managers, whether state, tribal or federal, on the same page? Exploration of the smoke impacts of 2017 and long-term policy implications will be explored in detail.

Keywords: Smoke, Risk, Policy, Economics

Bio: Pete Lahm is the Air Resource Specialist for the USDA Forest Service, State and Private Forestry, Fire and Aviation Management, in Washington, DC. He leads the Wildland Fire Air Quality Response Program which provides personnel, technical specialists called Air Resource Advisors, smoke modeling and monitoring capabilities to develop forecasts for areas adversely affected by smoke. Starting in 2004, Pete has led the Forest Service's national smoke management efforts developing technical approaches and policies related to smoke impacts from prescribed fire and wildfires. Since 2006 he has chaired the National Wildfire Coordinating Group's Smoke Committee.

042. Wildland Fire Smoke from Long-Range Transport Enhances Ozone in the Southeastern United States

Presenter: Nathan Pavlovic, Air Quality Specialist, Sonoma Technology, Inc
Additional Author(s): Steve Brown, Sonoma Technology, Inc., Petaluma, CA, USA
Theresa O'Brien, Sonoma Technology, Inc., Petaluma, CA, USA
ShihMing Huang, Sonoma Technology, Inc., Petaluma, CA, USA
Kenneth Craig, Sonoma Technology, Inc., Petaluma, CA, USA
Patrick Zahn, Sonoma Technology, Inc., Petaluma, CA, USA
Bryan Penfold, Sonoma Technology, Inc., Petaluma, CA, USA

The long-range transport of smoke from large wildfires can impact local air quality at locations very distant from source fires. Massive wildfire events in the last few years provide increasing evidence that substantial impacts can occur at distances of hundreds or even thousands of miles. In this presentation, we assesses an high ozone event in late 2017 in which smoke from dozens of large, fast burning wildland fires in the northwestern United States was transported over 1,500 miles to the southeastern United States, causing ozone to exceed the National Ambient Air Quality Standards. On September 14, 2017, air quality monitoring sites across Louisiana, Texas, Arkansas, and Oklahoma measured unusually high ozone concentrations, with many sites throughout the region exceeding the 99th percentile for daily maximum ozone concentrations over the previous 5 years. Using satellite retrievals of smoke aerosols and carbon monoxide, along with aerosol vertical profiles and meteorological models, we show that smoke was transported from northwestern fires to the southern United States over the course of a week. We then use data from meteorological models, a ceilometer, and radiosondes to show that smoke aloft was likely transported to the surface on the day of the ozone event. Finally, we use ground measurements of ozone, PM2.5, and other pollutants, as well as statistical regression, to demonstrate that surface air quality was actually affected by smoke brought to the region by long-range transport. This work suggests that air quality and public health agencies need to be aware of the potential of local air quality impacts from wildfires through long-range transport of smoke, and monitor for such events so that they can provide proper health advisories to the public. Cooperation between wildfire managers and other agencies can improve the communication of and response to health risks from future long-range smoke transport events.

Keywords: wildfire smoke, air quality, long-range transport, ozone

Bio: Nathan Pavlovic is an Air Quality Scientist at Sonoma Technology, Inc., where he supports wildfire-related science and analysis as a member of the Fire, Fuels, and Remote Sensing Group. He uses remote sensing, GIS, and data science tools calculate wildfire smoke emissions, to map fuels, and study air quality. Prior to joining STI, Mr. Pavlovic earned his master's degree in Geography and Geographic Information Science at the University of Illinois at Urbana-Champaign, where he assessed the geography of wildfire in West Africa.

043. Human Performance Optimization: A holistic approach to Improve Wildland Firefighter Performance, Well-Being, and Safety

Presenter: David Schary, Assistant Professor, Winthrop University
Additional Author(s): Waldron, Alexis, PhD, Human Performance Specialist, US Forest Service

Wildland firefighting requires a diverse skillset, ranging from fire knowledge to social interaction. As a result, good quality training is an integral part of being a successful firefighter. An often neglected area of training is the individual firefighter's human performance and well-being. To help bridge this gap in knowledge, in 2011 the Human Performance Optimization (HPO) course became a component of the Wildland Firefighter Apprenticeship Program (WFAP) in Sacramento, CA. This course prepares firefighters for the high risk and complex environment they will face through a unique curriculum centered on exercise physiology, nutrition, leadership, and performance psychology. It is consistently rated highly by students and is considered a coveted part of the apprentices' experience at the WFAP. In this presentation we'll discuss HPO's philosophy, objectives, curriculum, and benefits for firefighters and the organizations they serve. In addition, we will give examples of the content, show course feedback, and discuss the future of HPO.

Keywords: Performance, Safety, Exercise, Psychology, Nutrition, Training

Bio: Dr. Schary is an Assistant Professor of Exercise Science, specializing in performance psychology. His interests include performance, leadership, and well-being across a variety of domains. Currently, he is researching the effect of leadership on well-being and safety among wildland firefighters. Dr. Schary is an instructor for the Human Performance Optimization (HPO) course, a component of the Wildland Firefighter Apprenticeship Program.

044. Implementation of Network-Enabled GPS Tracking Units During Operations: Challenges and Opportunities

Presenter: Joaquin Ramirez, Principal, Technosylva
Additional Author(s): Santiago Monedero, PhD, Main Scientist, Technosylva
David Jones, Senior Implementation Lead, Technosylva

Use of GPS tracking devices capable of near real-time information relay to dispatching systems and incident management personnel are becoming more common. This technology offers opportunities for improving fireline personnel situational awareness, supporting operational decisions, and expediting planning unit functions. More detailed and accurate post-incident analyses can also be conducted with these data. However, challenges still exist with the implementation of this technology in the field and with the integration of this information into incident response decision making processes. This presentation will discuss several challenges and opportunities of deploying network-enabled GPS tracking devices during wildland fire response efforts. Several use cases, example implementations, and lessons learned will be provided from Technosylva's fiResponse and Tactical Analyst software – used by US and European wildland fire agencies – demonstrating the capabilities of radio, cell, and satellite technologies for improving wildfire situational awareness and tracking personnel and equipment.

Keywords: tracking, AVL, situational awareness. GPS

Bio: Founder and Principal Consultant at Technosylva, providing sophisticated fire behavior analysis and management software for wildland fire. Joaquin is well respected as a leading fire scientist and software architect in Europe and North America, and is the chief designer of the Wildfire Analyst™ and FiResponse™ software products.
As a Professor at the University of Leon, he teaches the first class on Geotechnologies and Wildfires at the first european MsC in Forest Fires www.masterfuegoforestal.es.
Since 2014 is based at the Innovation Space of the Qualcomm Institute at the UC San Diego.

045. An Analysis of Wildland Firefighter Entrapment Fatalities on Prescribed Fires and Wildfires, in the US, 1990 to 2017

Presenter: Richard McCrea, Wildland Fire Consultant, Wildland Fire Associates
Additional Author(s):

Introduction: In a 28-year period from 1990 to 2017, in the US, there were 35 incidents where firefighter entrapment fatalities occurred on wildland fires and prescribed fires, which resulted in 88 fatalities. The purpose of this analysis was to determine commonalities during entrapment's and to uncover and understand cause-effect relationships. By understanding the commonalities under which entrapment's occur, it will help improve research, training, decision making, and firefighter safety. This analysis does not include entrapment's where no fatalities occurred.

Problem Statement-The problem that needs to be addressed is: what are the commonalities that occur during fatality entrapment's including environmental conditions (e.g., fuels, weather, topography, climate) and the human factors (e.g., fire line tactics, communications, equipment).

Procedures for this Analysis:
Information for this analysis was obtained from investigative reports which included such sources as the Wildland Fire Lessons Learned Center, US Fire Administration, National Institute for Occupational

Safety and Health, California Dept. of Forestry, Texas State Fire Marshall, and the National Wildfire Coordinating Group.

A database was established using Microsoft Excel, to gather and analyze information. Ten main categories and 93 subcategories were established in the database. The main categories included: basic incident information, topography, fuels, weather, climate, NFDRS values, fire behavior, firefighter tactics, human factors, and incident reports.

Results of the Analysis:
The result of the analysis shows that there are commonalities that have occurred during wildland fire entrapment's. Important commonalities include:

1. The analysis spanned 28 years and 35 incidents
   - Average incidents per year: 1.25
   - Average # fatalities per year: 3.14
2. Topography:
   - 84% of the fatalities occurred in mountainous terrain
3. Climate:
   - 82% of the fatalities occurred when the Palmer Drought Severity Index was moderate, high, or extreme
4. Temporal
   - 51 % of incidents occur in the months of June, July and August. August accounts for 20% of all incidents
   - 60% of incidents occur between the hours of 1500 to 1700
5. Human Factors
   - Crew Tactics: 75% of fatalities occurred when fire crews were trapped while working upslope/upcanyon from the fire, when the fire made a sudden upslope/upcanyon run.

Conclusions:
Every entrapment is unique in its own way, however there are commonalities in entrapment situations across the US. This analysis produced a wide range of findings, however there were several significant conclusions which include the following:

- The number of incidents and fatalities in mountainous terrain (84% of fatalities)
- The number of incidents and fatalities during periods of drought (82% of fatalities)
- Human factors: 75% of fatalities occurred when fire crews were working above a fire, when the fire made a sudden upslope/upcanyon run
- Fatality entrapment's are trending downward, which began around 2006

This analysis can help focus the needs for research, assist policy makers in formulation and validation of fire polices, improve training, improve safety, and assist fire teams/firefighters in strategic and tactical decisions. Further research is needed into fatality entrapment's.

Keywords: firefighter safety, entrapments

Bio: Rich works as a wildland fire management consultant and freelance writer. During his career, he worked 32 years with the Department of Interior in fire management and forestry. Outfitted with a degree in Forestry, he started his career as a seasonal employee with the Forest Service as a forestry technician and member of the Helena Hotshot Crew, then moved on to permanent positions with the Bureau of Indian Affairs as a Forester and Fire Management Officer. Rich has considerable experience working with incident management teams including over 24 years' experience as a fire behavior analyst.

046. It's the thought that counts.

Presenter: Michael Williams-Bell, Assistant Professor, Durham College
Additional Author(s): Palmer, Charles G. Professor, University of Montana

It is widely recognized that wildland firefighting is extremely taxing upon the human body, both physically and mentally. While significant research data exists validating various physical costs of fire suppression, much less has been done in terms of understanding what impacts the job has upon mental functioning. A diverse array of factors, both external and internal in nature, presumably can and do impact psychological performance of firefighters, but to date, the scientific literature has not investigated this presumption too actively. The presenters will detail their participation in two different studies (one lab-based, one field-based), which have attempted to quantify the impacts that firefighting activities and environmental exposures have upon cognitive functioning.

Keywords: wildland firefighting, cognitive functioning

Bio: Dr. Michael Williams-Bell is a Professor at Durham College in Oshawa, Ontario, and an Adjunct Professor at the University of Ontario Institute of Technology. His research program aims to improve fire fighter health and safety through technological advances in training by incorporating virtual and augmented reality simulations while better understanding how the body's physiological systems respond to physical and psychological stressors. During his PhD studies, Michael obtained an Australian Endeavour Research Fellowship where he collaborated with Dr. Brad Aisbett's group at Deakin University to examine the physiological demands and cognitive responses of wildland firefighters under very hot conditions.

047. An Operational Fire Weather Alert System

Presenter: Tanner Finney, Engineering Aid, United States Forest Service, Missoula Fire Sciences Laboratory
Additional Author(s): Forthofer, Jason, Mechanical Engineer, Missoula Fire Sciences Laboratory U.S Forest Service
Wagenbrenner, Natalie, Research Meteorologist, Missoula Fire Sciences Laboratory U.S Forest Service
Butler, Bret, Research Mechanical Engineer, Missoula Fire Sciences Laboratory U.S Forest Service

Many firefighters have been injured or killed due to rapid changes in weather causing unexpected fire behavior. Examples include the thunderstorm outflow that killed 19 on the Yarnell Hill Fire, the cold front passage that killed 14 on the South Canyon Fire, and the wind shift that killed 3 on the Twisp River Fire. Many of these weather events can easily be predicted and observed by tools that exist today (e.g., short-term high-resolution forecast models, radar data, nearby weather stations). Tragically, these tools and the data they provide are underutilized by on-the-ground firefighters, which leads to many preventable accidents. Some of the reasons for underutilization are that: 1) this information is difficult to access on mobile devices in the field, 2) the information is scattered among several web sites, 3) some of the information is difficult to interpret because it is intended for weather experts, and 4) firefighters do not have much time to devote to gathering this weather information. A new prototype system called the Fire Weather Alert System has been developed to alleviate many of these issues. Users simply provide the system with a location and custom weather thresholds to watch for. The system continuously checks the many data sources that exist for exceedance of those thresholds. Thresholds can be set for wind speed, temperature, relative humidity, precipitation, thunderstorms, and National Weather Service issued Watches, Warnings, or Advisories. When one of these thresholds is reached, either from a nearby weather station, a short-term forecast, radar data, etc., the user will be alerted. The alert includes information about what threshold was met, where, and from what source (a RAWS station, forecast, etc.). Users can be alerted via text message or email. This prototype system could be converted from a web application (which is accessible via a browser on a mobile device) to a stand-alone mobile application with a cleaner and even easier to use interface. Additional functionality and data sources (e.g., lightning detection) could also be added. The application could also be used to initiate alerts regarding non-burnover-related hazards such as lightning safety, flash floods, muddy impassible roads, and others. The alert system is designed to provide on-the-ground users with an easy-to-use custom weather delivery system that has the potential to increase safety and inform decision making on wildland fire incidents.

Keywords: Fire Weather, Firefighter Safety

Bio: Tanner Finney works as an Engineering aid at the Missoula Fire Lab, and is a chemical engineering student at Montana State University.

049. Dead woody debris fuel load for Canadian forests

Presenter: Chelene Hanes, Forest Fire Research Specialist, Canadian Forest Service, Natural Resources Canada
Additional Author(s): Letang, Danielle, Senior Policy Advisor, Ontario Ministry of Natural Resources and Forests
de Groot, William, Research Scientist, Canadian Forest Service, Natural Resources Canada
Wang, Xianli, Research Scientist, Canadian Forest Service, Natural Resources Canada

Dead woody debris (DWD) plays an important role in forest ecosystem structure and function, as well as wildland fire behaviour. Despite its significance, there is no national assessment of its spatial distribution as well as factors that control its accumulation and occurrence. DWD size, load, and distribution are important to many forestry related questions, which are difficult to answer because they vary greatly both spatially and temporally. Despite this complexity there is a growing need to understand its national distribution, particularly for wildland fire modelling. To remedy that, this study compiled multiple datasets to create a national database of DWD across Canada, and quantified factors that influence DWD accumulation and distribution. Data were separated into three size classes: fine (<1cm), medium (1-7 cm) and coarse (>7cm) woody debris. Dominant tree species, ecozone, age class and drainage class were found to have a significant effect on DWD fuel loads based on ANOVA and regression analysis, but only ecozone and species were substantially influential. Additional variables (stand biomass, tree density and diameter at breast height) were also included in the analysis, but they did not explain additional variability for any of the size classes. Exploration of the influence of climatic variables did result in additional explanatory power to the models. The resultant database of DWD fuel load, which was summarized by size class, ecozone and

species, is an important input required to improve the flexibility of models for wildland fire and forest management. These types of data are needed to allow a more quantitative assessment of fuels in fire behaviour models in Canada.

Keywords: fire behaviour, fuel load, boreal, down woody debris

Bio: Chelene Hanes is a physical scientist with the fire and climate change group at the Great Lakes Forestry Centre, a Canadian Forest Service laboratory in Sault Ste. Marie, Ontario, Canada. She conducts studies in fire danger and fire behavior using spatial analysis tools including remote sensing and geographic information systems. Chelene has recently started her PhD with Dr. Mike Wotton at the University of Toronto, Faculty of Forestry.

050. Fuel Dynamics along a Climatic Continuum: Insights from Australia's most Dangerous Fuel Type

Presenter: James M Furlaud, PhD Student, University of Tasmania
Additional Author(s): David MJS Bowman

Tall wet eucalypt forests are a globally unique ecosystem present across the wetter forested areas of the continent of Australia. They are characterised by a highly flammable Eucalyptus overstorey and a structurally complex understorey whose composition ranges from moderately flammable shrubs to extremely fire-sensitive rainforest species. Their very long fire return interval (sometimes hundreds of years) allows for massive accumulation of fuels that could potentially result in some of the highest fire intensities on Earth. However, there is little empirical data describing the loads and vertical continuity of these forests' fuels. Quantifying these elements of the fuel structure is critical in order to calibrate fire-behaviour models for this fuel type. Furthermore, understanding how the fuel structure of these forests varies across Australia's diverse climate is critical in understanding how the fire danger in these forests will alter in response to climate change. To remedy this we measured fuel loads across the TERN Ausplots Forest Monitoring Network: a network of 48 permanent plots in mature tall wet eucalypt forests across the continent. These plots are located in cool-temperate, Mediterranean, subtropical, and tropical climates. We examined the fire danger in these forests through the prism of the four-switch model: analysing the fuel loads, availability to burn, fire weather, and likelihood of ignition. We estimated fuel loads and fuel moisture using field data from the plots, and fire weather using data from nearby weather stations. We used these data to run Monte-Carlo simulations on fire-behaviour equations predicting flame height. This allowed us to estimate the probability of ignition in each of the fuel layers and understand how the fire regimes in these forests vary with climate. We found the vertical structure of these forests to be complex and variable, suggesting a need for more dynamic representation of fuels in current fire behaviour models that treat fuel as a singular mass. More broadly, we found that climate does affect fire regime, particularly the availability to burn and ignition probability, across Australia's wet eucalypt forest estate. This could provide important insight into how climate change will alter fire regimes, especially those of the cooler, wetter forests of Australia's densely populated southeast. This research provides an important framework for investigating how fire regimes will respond to climate change. It underscores the importance of understanding the complexities of fuel arrays across macroecological gradients in order to improve fire-behaviour prediction models.

Keywords: Fuel Dynamics, Wet Eucalypt Forests, Climate Change, Flammability, Fire Behaviour Models, Fire Weather

Bio: James Furlaud is a PhD student at the University of Tasmania in Australia. Originally from the United States, a passion for the outdoors has led to a decade of field experience conducting scientific research in forests across the world. He also pursued a keen interest in statistics through a Master's in forest biometrics at the University of Montana. This combination of field experience and statistical fluency has led to a unique understanding of forest ecology. He hopes to apply this understanding to fire behaviour models so that they may better reflect the complexities of forest fuels, better predicting fire behaviour.

051. Estimating Litterfall Rates Following Stand-replacement Disturbance in Northern Rocky Mountain Ecosystems

Presenter: Christine Stalling, Biologist, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory
Additional Author(s): Robert E. Keane, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory
Molly Retzlaff, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory

It is generally assumed that insect and disease epidemics, such as those caused by the mountain pine beetle, predispose damaged forests to high fire danger by creating highly flammable fuel conditions. While this may certainly be true in some forests, these dangerous fuel conditions may only occur for a short time when evaluated at a landscape level. This study evaluates the effect that exogenous disturbance events, namely fire and beetles, have on future fire hazard. We measured surface fuel deposition rates several forest types after stand-replacement wildfire beetle outbreaks to quantitatively describe fuel dynamics in heavy mortality stands for up to 10 years post disturbance. Fuel deposition was measured using semi-annual collections of fallen biomass. This litterfall was collected using a network of seven, one meter square litter traps installed on sites located across the northern Rocky Mountains USA. We also measured stand and surface fuel characteristics of the plot using FIREMON techniques at the beginning, and yearly until the study's end. Results indicate that after the initial pulse of needlefall 2-3 years after disturbance, few fine woody fuels are actually deposited over the next 10 years.

Keywords:

Bio: Chris Stalling is a biologist with the Fire, Fuels and Smoke Program at the Missoula Fire Science Lab, Rocky Mountain Research Station. She is interested in landscape ecology and ecosystem disturbance dynamics. Current research includes whitebark pine restoration, fuel dynamics, and large scale ecosystem modeling in planning efforts.

052. Modelling bushfire fuels using biophysical parameters

Presenter: Meaghan Jenkins, , Centre for the Environmental Risk Management of Bushfires, University of Wollongong, Australia.
Additional Author(s): Bedward, Michael, Risk Programmer, Centre for Environmental Risk Management of Bushfires, University of Wollongong, Australia
Price, Owen, Senior Fellow, Centre for Environmental Risk Management of Bushfires, University of Wollongong, Australia
Bradstock, Ross, Professor, Centre for Environmental Risk Management of Bushfires, University of Wollongong, Australia

Environmental gradients that drive landscape structure, productivity and fuel accumulation have the potential to provide more detailed, fine-scale prediction of fuel hazard, without the need for exhaustive and labour intensive field estimation. Fuel hazard scores allow a rapid visual assessment of fuel and provide fire and land management agencies with a measure of the chances of controlling a bushfire. This study examined how measures of fuel hazard varied with biophysical parameters. Generalised additive modelling showed that time since last fire, temperature, precipitation, region, soil and fire type were the strongest predictors of fuel hazard across New South Wales, Australia. We found that biophysically modelled fuel hazard performed better than currently used operational models, but both tended to over-estimate at lower fuel hazard and under-estimate at higher fuel hazard. With increased data collection of fuel hazard measures across all regions and advancement of spatial data, these models can be significantly improved over time.

Keywords: Fuel Hazard, Biophysical Modelling, Bushfire Fuels.

Bio: Dr Meaghan Jenkins is a Research Fellow in Fire and Environmental Modelling within the Centre for Environmental Risk Management of Bushfires, University of Wollongong, Australia. Her current work focuses on quantifying bushfire fuels and fire behaviour modelling. She completed her PhD at the UNSW in 2009, examining carbon cycling in sub-alpine ecosystems. A post-doctoral fellowship at the University of Sydney, examining fires, black carbon, greenhouse gas emissions and carbon balance of southern sclerophyll forests. In 2014, she joined the University of Wollongong examining environmental values and fire hazard of eucalypt plantings.

053. Simulating the effectiveness of prescribed burning at altering wildfire behaviour in Tasmania, Australia

Presenter: James M Furlaud, PhD Student, University of Tasmania
Additional Author(s): Williamson, Grant J, Postdoctoral Fellow, University of Tasmania
Bowman, David MJS, Professor of Environmental Change Biology, University of Tasmania

Prescribed burning is a widely accepted wildfire hazard reduction technique; however, knowledge of its effectiveness remains limited. To address this, we employ simulations of a widely used fire behaviour model across the ecologically diverse Australian island state of Tasmania. We simulate three broad scenarios: (1) no fuel treatment, (2) a maximal treatment, with the most possible prescribed burning within ecological and social constraints, and (3) 12 hypothetically implementable prescribed-burning plans designed by fire managers. In all simulations, we standardised fire-weather inputs to represent regionally typical dangerous fire-weather conditions. Statistical modelling showed that an unrealistically large maximal treatment scenario could reduce fire intensity in three flammable vegetation types, and reduce fire probability in almost every vegetation type. However, leverage analysis of the 12 more-realistic implementable plans indicated that such prescribed burning would have only a minimal effect, if any, on fire extent and that none of these prescribed-burning plans substantially reduced fire intensity. This study represents the largest geographical- and ecological-scale fire-behaviour simulation study in the peer-reviewed literature. It highlights that prescribed burning can theoretically mitigate wildfire, but that an unrealistically large area would need to be treated to affect fire behaviour across the island. Rather, optimisation of prescribed burning requires careful landscape design and intensive treatment at the local scale. Such designs should be based on improved fire behaviour modelling, empirical measurement of fuels and analysis of actual wildfires.

Keywords:

Bio: James Furlaud is a PhD student at the University of Tasmania in Australia. Originally from the United States, a passion for the outdoors has led to a decade of field experience conducting scientific research in forests across the world. He also pursued a keen interest in statistics through a Master's in forest biometrics at the University of Montana. This combination of field experience and statistical fluency has led to a unique understanding of forest ecology. He hopes to apply this understanding to fire behaviour models so that they may better reflect the complexities of forest fuels, better predicting fire behaviour.

054. Revisioning fuels measurements using a novel 3D fuels sampling technique and remotely sensed data

Presenter: Eric Rowell, Remote Sening Analyst, National Center for Landscape Fire Analysis, The University of Montana
Additional Author(s): Loudermilk, Louise, Research Ecologist, Southern Research Station, USFS
Hiers, Kevin, Fire Scientist, Tall Timbers Research Station
Hudak, Andrew, Research Forester, Rocky Mountain Research Station, USFS
Skowronski, Nicholas, Research Forester, Northern Research Station, USFS
Varner, Morgan, Research Biological Scientist, Pacific Northwest Research Station, USFS
Queen, LLoyd, Director, FireCenter, The University of Montana

Advances in the characterization of fuels using technologies as airborne and terrestrial lasers and unmanned aerial systems (UAS) necessitates a revisioning of how we sample in situ fuels. These remotely sensed data demonstrate the potential to represent fuels at fine grain sizes that can be aggregated to landscape scales both two and three dimensionally. We note that conventional fuels inventory relies on two dimensional sampling that is at best a generalization of the fuels that may be encountered at a site. At the core of these advances in sampling fuels is an understanding of how LiDAR and PhoDAR, a photogrammetric process that produces structure from motion based point clouds, methods measure fuelbeds and how these characterizations intersect with field measurements. In this talk, we discuss a novel three-dimensional fuels sampling technique that samples fuels as voxels (100m3) and discretizing fuels by type, position in the fuelbed, and mass. We relate measurements to the three dimensional fuel sampling method with terrestrial LiDAR and PhoDAR based voxel estimates of occupied volume for frequently burned pine systems in the Southeastern United States. We estimate fuel mass and bulk densities of the fuelbed and integrate assumptions of fuel type from the photo mosaics generated from the UAS system at fine grain size (≤0.25m2). Based on our work in longleaf pine ecosystems at Eglin Air Force Base in Florida, USA, occupied volume has demonstrated significant relationships with total fuel mass (Adj. R2 0.71-0.84). These findings are of importance for longleaf pine ecosystems and other similarly structured ecosystems that are frequently burned - globally. This ability to cross-walk field measurements to the remotely sensed data allows for enhancement of three-dimensional spatially explicit fuels maps that are scalable to landscape levels; thus enhancing estimates of fire behavior and risk mapping.

Keywords: LiDAR, PhoDAR, UAS, Surface Fuels, Frequently Burned Ecosystems

Bio: Eric Rowell has been working with LiDAR systems for 17 years, developing techniques that aid in characterizing fuels.

055. A site suitability index for remote automated weather stations (RAWS) in Washington State using a weighted linear combination scheme

Presenter: Joshua Clark, Meteorologist, Washington State Department of Natural Resources
Additional Author(s): Davis, Kirk, GIS Analyst, Washington Department of Natural Resources

Remote automated weather stations (RAWS) play a critical role in determining fire weather conditions, establishing fire danger ratings, predicting fire behavior, forecasting smoke dispersion, and informing fire operations decisions. Most importantly, these stations are suitable for revealing rapidly changing atmospheric conditions that may threaten firefighter and public safety. However, over the past few decades, changes in fire occurrence patterns, forest health, increased wildland-urban interface, climate, and management strategies have challenged the usefulness of RAWS to adequately describe the current fire environment. The obvious solution points towards adding new RAWS or re-siting existing ones. But, how do you determine where to site or re-site a RAWS effectively with respect to the current network, environmental variables, and agency objectives?

In this study, we refined the RAWS Uniqueness Index (RUI) from Brown et al. (2012) by performing a geospatial analysis of 92 stations across Washington State, yielding a site suitability index based on three major criteria: fire occurrence, terrain complexity, and proximity to other observing stations. These criteria were linearly combined with weightings determined by an expert system generated from interviews with local, state, and federal fire managers. This index extends the RUI through the addition of fire occurrence, modified input variables, and an expert-defined weighting of criteria. Results were then interpolated using inverse-distance weighting and an overlay analysis was performed using state fire agency jurisdictional boundaries. Index values range from low (0.0) – areas well represented by current RAWS, to high (1.0) – areas poorly represented that would benefit from the placement of a station nearby. Early findings show four state land blocks suitable for future RAWS placement identified by index scores one standard deviation (0.09) above the statewide mean (0.76). These methods will be useful in future analyses to determine other potential RAWS locations that would improve statewide network coverage while effectively describing the evolving fire environment.

Keywords: Washington, remote automated weather stations, RAWS, mesonet, fire danger ratings

Bio: Josh Clark is the meteorologist for the Washington Department of Natural Resources. In this position, he provides decision support services and products for agency and state leadership during wildfires and other natural disasters. He also manages the state's remote automated weather station network and serves on incident management teams as an incident meteorologist and situation unit leader (trainee). Josh previously worked for MesoWest, the National Center for Atmospheric Research, and the Rocky Mountain Area Coordination Center. He attended school at the University of Northern Colorado for meteorology and the University of Idaho for fire science.

056. The Diablo Wind and Extreme Fire Behavior during the 2017 Wine Country Fires
Presenter: Carrie Bowers, , San Jose State University
Additional Author(s): Clements, Craig, SJSU

In California, extreme fire behavior is often associated with strong offshore winds. Santa Ana winds, offshore wind events specific to Southern California, have been the driving force behind many of the area's most devastating fires. Similarly, Sundowner winds in the region of Santa Barbara originate inland and accelerate downslope as they flow towards the ocean, over the Santa Ynez Mountains. In the San Francisco Bay Area, an analogous situation arises when north winds flow into Northern California's Central Valley and are forced over coastal terrain. Named for the Diablo Range section of the Coast Ranges, the "Diablo winds" create the area's most extreme fire behavior with their low relative humidities, high temperatures, and very high wind speeds. The focus of this study is to define and categorize Diablo wind events based on a 17-year climatology of regional surface weather stations. Analyses of the frequency and spatial distribution of events indicate a mean annual event frequency of 9.6 and 15.8 for the East and North Bay, respectively. While events have occurred at all times throughout the year, the highest frequency of events was in the Fall and Winter, with the summer months having the lowest frequency. The East Bay experienced more severe events during the 17-year study than did the North Bay. For both regions, no severe event was recorded during the summer months. This study also includes synoptic composites derived from the days that were associated with severe, moderate, and weak Diablo wind events. Additionally, this talk will describe a numerical study of the 2017 Tubbs Fire event, driven by Diablo winds, using the Weather Research and Forecasting (WRF) model at 300 m horizontal resolution.

Keywords:

Bio: Carrie Bowers is a MS student in the Department of Meteorology and Climate Science at San Jose State University. Carrie joined the Fire Weather Research Lab at SJSU after working as a wildland firefighter with the US Forest Service for 9 years.

057. The use of remote sensing and coupled weather-fire modeling for hazard identification and testing mitigation impacts in the northern Sierra Nevada Mountains
Presenter: Janice Coen, Project Scientist, National Center for Atmospheric Research
Additional Author(s): Tarnay, Leland, USDA Forest Service/National Park Service
Conway, Scott, Spatial Ecologist, USDA Forest Service

Western forests are at risk for large, severe wildfires that can arise from dynamic interactions between fuels in forests shaped by drought, previous fires, and other disturbances, steep, complex terrain, and complex mountain winds including winds amplified by the fire itself. Forest management aims to mitigate the extent and impact of such fires by strategic manipulation of forest fuel amount and structure but to date, plans and standard fire behavior models used to test them have not considered these dynamic interactions and thus may misinterpret fuel impacts.

Advances have been made in the remote sensing of fuels, notably with lidar, both airborne and terrestrial. Fuel information derived from lidar is now available over large tracts of the northern Sierra Nevada mountains and, through other efforts, being used to improve community databases such as LANDFIRE. Concurrently, the ability to simulate fire weather and behavior in complex weather, fuel, and terrain conditions has advanced due to coupled weather - fire models, numerical weather prediction models designed to capture fine-scale circulations in complex terrain that are coupled to fire behavior models, thereby capturing the effects of fire-induced winds on fire behavior.

In this work, we use lidar-derived fuel data and the CAWFE coupled weather-fire model to (1) test the sensitivity of locations within Tahoe National Forest to rapid fire growth additionally considering fire-scale circulations and fire-induced winds, and (2) test fire growth under standard and lidar-enhanced fuel datasets, and (3) test planned and hypothetical mitigation strategies. With these advaned tools, we find significant differences in susceptibility to fire, as well as impacts of various treatments, and discuss how this approach could be used to virtually evaluate and improve the efficiency and effectiveness of fuel treatments.

Keywords:

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

058. Using Fire Weather Data in Tactical Decision-Making: the Dream and the Reality
Presenter: Christine Olsen, Research Social Scientist, Oregon State University
Additional Author(s): Rapp, Claire, PhD Student, The Ohio State University

Many fire weather-based tools, such as the National Fire Danger Rating System (NFDRS) and the Wildland Fire Decision Support System (WFDSS), are used nationwide to support the full range of strategic (pre-fire and prescribed fire planning) and tactical (initial and extended attack) wildland fire management decisions. However, little is known about which of these tools most heavily impact fire management decisions. In this presentation we share findings from nearly 30 exploratory interviews conducted among fire management professionals across the western United States, asking how fire weather data is used during a fire event. This information is being used to inform additional phases of research that will examine this process in greater depth. Preliminary findings include what data sources and models are most used, how they are used, what other factors are weighed against this forecasted information in choosing a tactical strategy, and which events can supersede a course of action as predicted with models. We also explore limitations to this data and information needs that are not adequately address with current fire weather tools.

Keywords:

Bio: Christine Shaw Olsen, Ph.D., is a former Research Social Scientist in the Department of Forest Ecosystems & Society at Oregon State University in Corvallis, Oregon. Dr. Olsen conducted 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 examined fire weather modeling and manager decision-making, 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 and sustainable natural resource management.

059. Innovation in Early Detection – Real-Time Surveillance for Private and Commercial Use

Presenter: Anna Zielinska, Product Manager, IT for Nature
Additional Author(s): Anna Zielińska, Product Manager, IT for Nature
Andrzej Bytnerowicz, Senior Advisor, IT for Nature
Terry Levesque, Business Development Manager, IT for Nature

Flash fire detection is the first and most important link of the firefighting chain, however, it is often overlooked in financial and logistic plans of numerous organizations responsible for fighting fires. Understandably, local, state, and federal firefighting units invest primarily in means to suppress and put out a possible fire. Usually, the reason why flash fire detection is impossible to implement entails gigantic installation costs of surveillance and detection spots, totaling up to 5080 thousand US dollars per said spot.

There emerged, however, new technologies which can not only lower surveillance costs, but also increase its range. These technologies stem from the awareness that early smoke detection is half the battle when it comes to firefighting. They are an investment which can save human lives as well as thousands of hectares of valuable land.

The aim of this presentation is to introduce an innovative IT solution enabling real-time surveillance of an area with use of specialist cameras, as well as software designed to assist in early smoke detection. Past implementations in the USA and Europe constitute a valuable source of reliable statistical data proving the system's efficacy and its financial efficiency.

The presentation will also include the topic of artificial intelligence (AI) utilized in landscape surveillance as well as smoke and flame detection on the horizon. AI has grown exponentially over the last few years and might replace humans in many fields. Thanks to our tests and past implementations, we are able to present the impact AI has on firefighting and compare its efficacy with the most popular surveillance method so far – human observation.

The last issue on the agenda entails presenting how to engage communities in early detection thanks to the implemented fire surveillance systems. Communities are often unaware that their dwellings constitute great surveillance spots for the immediate surroundings. A real-time surveillance system installed in such places could form a dense infrastructure without investing large financial resources.

Keywords: wildfire detection, artificial intelligence, fire cameras

Bio: CEO in IT for Nature since 2015; actively developing and implementing new IT technologies in forestry and nature conservation for almost 20 years; since 2013, focused on the automatization of the smoke detection processes with help of AI. Artur combines his passion for the newest technologies with the deep care for natural resources and human lives, and has broad experience as forester and manager. Privately, running and water sports enthusiast.

061. Direct Numerical Simulation of a Turbulent Helium Plume and Methane Pool Fire
Presenter: Nicholas Wimer, , University of Colorado, Boulder
Additional Author(s): Amanda S. Mackoweicki
Jeffrey F. Glusman
John W. Daily
Gergory B. Rieker
Peter E. Hamlington

Preliminary results are presented from a new research effort focused on understanding and characterizing wildland fire spread at small scales (roughly 1m-1mm) using direct numerical simulations (DNS). The simulations are intended to directly resolve, with high physical accuracy, all small-scale fluid dynamic and chemical processes relevant to wildland fire spread. As a preliminary validation study, DNS is performed for two canonical test cases that exhibit many of the fluid-dynamical and chemical processes of wildland fires: a turbulent helium plume and a reacting methane pool fire. Here preliminary results are shown comparing the direct numerical simulations and experimental data. The results are connected to the fundamental structure and spread of wildland fires, and an outlook is provided for the future expansion of these DNS studies.

Keywords: pool fire, plume dynamics, DNS, wildland fire

Bio: Nicholas is a PhD student at the University of Colorado, Boulder in the Mechanical Engineering department studying wildland fires using direct numerical simulation.

062. Real-Time Smoke Management Support using Paired Fuel/Atmosphere Risk Assessment with a Web-based Decision Support System
Presenter: Erin Law, , SmokechasersInk LLC
Additional Author(s): Mavko, Matthew E, Principal Air Quality Scientist, Air Sciences Inc.

Regulation that limits ambient levels of fine particulate is frequently perceived as a bottle-neck to the accomplishment of wildland prescribed burning. Any interruption to the fuel consumption piece of the fire management continuum can exacerbate the potential duration and intensity of latent energy release across fire-adapted landscapes, slow redevelopment of ecosystem heterogeneity and can hamstring the operational productivity of land managers. In contrast, the Montana and Idaho Departments of Environmental Quality and major open burners across all agencies and organizations in both states together participate in a science-based burn recommendation process supported by spatially and temporally-resolved burn data in an Airshed Management System (AMS) that, for the past 10 years, has been able to report no loss of annual accomplishment and minimal complaints and intrusions across its membership. The success of the Montana/Idaho Airshed Group (MIAG) smoke management framework is driven by its burner-designed architecture developed cooperatively with the MT DEQ in the early '70s that continues to evolve with burner ideas and input in pace with evolving technology and regulatory direction. Multiple aspects of the MIAG's intrinsic design enable the necessary communication for accurate and timely decision support, in particular the optimized data input and display designs within the AMS that share both fuels and meteorology intel and feedback, yet the MIAG structure also includes positions and protocols designed to protect the burner from distraction in the fire environment once ignition has occurred. Perhaps most significant is the objectivity offered by its mathematical treatment of the go/no go ignition recommendation. Spatially and temporally-resolved ignition data are treated in the context of signal detection theory (SDT), i.e. a burn lit with no adverse smoke impacts is a 'hit' and a restricted burn that would have

had smoke impacts is a correct rejection: it is equally as important to allow a burn that will have no smoke consequences as it is to restrict a burn that might. A burn conducted by a member that causes smoke impacts is a 'miss', and regardless of its magnitude is considered serious and its source cause investigated commensurate with complexity. A restricted burn that would not have resulted in adverse smoke impacts is the proverbial false alarm. It is in avoiding false alarm calls that the paired risk assessment decision model is most effective, and in doing so, it affords more frequent burn opportunities and strengthens affirmative support and compliant participation from MIAG member burners.

Keywords: smoke management, prescribed burning, decision support, Signal Detection Theory, Airshed Management System

Bio: Erin operates SmokechaserInk LLC in Grangeville, Idaho, which specializes in smoke monitoring and mitigation strategies and implementation. She is the recently-retired Smoke Management Program Coordinator for the Montana/Idaho Airshed Group. Prior to working for the Airshed Group, she was a career fire manager specializing in long-duration fire planning and management. Matthew E. Mavko is a Principal Air Quality Scientist at Air Sciences Inc. in Portland, Oregon. His work includes development of web-based Airshed Management Systems in Montana, Idaho, Utah and Arizona.

063. Calculation of smoke dimensions and estimation of affected area using calibrated optical sensors

Presenter: Andreas Jock, , IQ wireless GmbH
Additional Author(s):

Natural wildfire plays a fundamental ecological role in many wild land areas.
However, the rising number of homes and infrastructure in the woodland-urban interface as well as climate changes result in increasing risk and escalating costs of wildfire management.
Current wildfire detection techniques in the US are primarily public reporting via 911 calls and in critical areas manned towers, aerial patrols, ground patrols and occasionally automated wildfire detection systems. Such measures are obligatory to support rangers in their work to prevent mayor wildfire hazards.
Since fire fighting resources are limited and during the hot seasons many wildfires start in parallel 911 calls and automated detection are not able to deliver sufficient data regarding the extend of each individual wildfire. As a consequence inappropriate measures are taken and manageable tasks are getting out of control.
Recently developed algorithms in combination with calibrated optical sensors are able to detect smoke and calculate the dimensions of the occurring clouds in parallel and provide forecasts regarding the affected areas.
That said, several parameters have to be considered to compute reliable information for the fire fighting forces:

- Use of calibrated optical sensors with fixed focal length
- Elimination of unwanted platform movement
- Sophisticated calibration process in factory and during installation
- Use of digital terrain models in combination with sensor images
- Backward projection from sensor images to a digital map and estimation of affected area on the ground
- Calculation of smoke size from single and multiple sensors
- Defined interface to common GIS-systems

This approach deems capable of acting as a basis of decision for the responsible officers managing the wildland-urban interface and can theoretically be applied also for larger areas.
We are currently preparing an operational pilot study to confirm the feasibility of an operational system and add confidence in the system capability.

Keywords: detect smoke and calculate the dimensions of the occurring clouds in parallel and provide forecasts regarding the affected areas to compute reliable information for the fire fighting forces

Bio: About the author Dipl.-Ing .Andreas Jock:
Studied Information engineering at Technical University of Dresden 1987-1992. Graduated as Diplom-Ingenieur. Worked for different companies as designer for embedded hard- and software.
From 2003 working with the FireWatch system as responsible developer for hard and software at IQ-wireless GmbH Berlin. (Co-)Author of different algorithms and patents in the fields of image processing and smoke detection.

064. U.S. Fine Particulate Matter Air Quality Improves Except in Wildfire Prone Areas
Presenter: Crystal McClure, PhD Candidate, University of Washington
Additional Author(s):

We examined over 150 sites in the IMPROVE network across the contiguous U.S. to determine the link between wildfires and trends in fine particulate matter (diameter < 2.5 µm [PM2.5]) for 1988-2016. Through the use of advanced statistical methods, we calculate trends in the significantly non-normal PM2.5 datasets and determine the spatial extent of the positive/negative trends in PM2.5. We conclude that while the majority of the U.S. is experiencing a decrease in PM2.5, summer-time PM2.5 concentrations in the Northwest U.S. are increasing (especially during extreme events). We determine that this increase in PM2.5 is correlated with wildfire influences using tracer species and seasonal analyses. Specifically, we find a positive PM2.5 trend of 0.025 µg/m3/yr during the summer/wildfire season in the Northwest U.S. This is in contrast with the rest of country during summer/wildfire season (-0.187 µg/m3/yr) and with the entire U.S. during the non-summer season (-0.109 µg/m3/yr). We also examine the trend in extreme PM2.5 events. At the 98th quantile (EPA regulation threshold), the trend in summertime PM2.5 in the Northwest U.S. shows an increase of 0.141 µg/m3/yr compared with the rest of the country at -0.506 µg/m3/yr. These results indicate a statistically significant decrease in PM2.5 over most of the country but an increase in Northwest PM2.5 events during summertime due to wildfires. Overall, these findings are significant when coupled with recent studies which suggest that wildfire extent and duration will increase in the future. With increasing wildfires, it is likely that exceedances of the PM2.5 air quality standard in the Northwest will become an intensifying issue in the future.

Keywords:

Bio: Crystal McClure is a PhD Candidate in the Department of Atmospheric Sciences at the University of Washington. She received her B.S. in Meteorology from Texas A&M University in 2011 and M.S. in Atmospheric Sciences from the University of Washington in 2014. She expects to complete her PhD dissertation in May 2018. Her general research topic is examining wildfire emissions and the effect these emissions have on urban and rural air quality in the western U.S.

067. An examination of fuel moisture, energy release, and emissions during laboratory burning of live wildland fuels

Presenter: Ellicott Evan, Research Assistant Professor, Department of Geographical Sciences, University of Maryland, College Park
Additional Author(s): Nathaniel May, University of Maryland
Michael Gollner, University of Maryland

A series of small-scale laboratory fires were conducted to study the relationship between fuel type, moisture content, energy released, and emissions during the combustion process. The experimental design sought to understand the effects varying moisture content of different fire-promoting plant species had on the release of total energy, gaseous emissions (CO, CO2), particulate matter (PM2.5), and fire radiative energy (FRE). Instantaneous FRE, or fire radiative power (FRP), is an important parameter used in remote sensing to relate the emitted energy to the biomass fuel consumption. Currently, remote sensing techniques rely on empirically-based linear relationships between emitted FRE and biomass consumed. However, this relationship is based on the assumption that all fuels emit the same amount of energy per unit mass, regardless of fuel conditions (type, moisture, packing, orientation, etc.). In this study, we revisited these assumptions under the influence of moisture content for species that are adapted to fire, containing volatile oils. Results showed that while the total energy released was not dependent on the fuel type and only slightly dependent on the moisture content, the amount of FRE released and emissions is slightly dependent on the fuel type and very dependent on the moisture content of the fuel.

Keywords: smoke, live fuels, emissions

Bio: I am a Research Assistant Professor at the University of Maryland, College Park. My research focus is on the examination of geospatial data to describe and characterize biophysical phenomena and the interactions with society. One of my topics of study is biomass burning, specifically wildland fires, in a changing physical and social environment. I am a Joint Polar Satellite System (NOAA and NASA) Suomi NPP science team member tasked with VIIRS Active Fire product calibration and evaluation. I am also the Principle Investigator for NOAA's Proving Ground and Risk Reduction (PGRR) project focused on the VIIRS AF products.

069. Laboratory Analysis of Gas Emissions from Southeastern Forest Fuels

Presenter: Adam Coates, Assistant Professor, Virginia Tech
Additional Author(s): Dukes, Christopher, Graduate Research Assistant, Virginia Tech
Seiler, John, Ph.D., Professor, Virginia Tech, Dr. Alex Chow, Associate Professor, Clemson University, Mr. James H. Dozier, Wildlife Biologist, South Carolina Department of Natural Resources, Tom Yawkey Wildlife Center

Smoke management and dispersal is of critical concern for wildland fire professionals. Visibility may become an issue for fire managers, for example, and this may create strategic and physical impediments for effective fire management. Humans may also be negatively affected by the inhalation of wildland fire smoke. Of the ecosystem processes and properties studied through the decades of fire science, smoke and gas chemistry remains one of the components less investigated, however. As a result of these concerns, we sought to investigate potential gas emissions arising from laboratory-burned forest floor materials of Southeastern US forests. In this presentation, we discussed potential gas emission concerns noted at a variety of field and firing conditions that may simulate differing fire intensities.

Keywords: Emissions, Fuels, Chemistry, Southeast

Bio: Adam Coates is the Assistant Professor of Forest Fire Ecology and Management at Virginia Tech. Adam began his career as a fire ecologist investigating fuels and fire behavior in the Chauga Ridges of South Carolina. Since that time, he has studied fire and its effects at multiple scales, ranging from soil microbial responses to regional vegetative compositions. His current research in the Appalachian Mountains and Southeastern Coastal Plain has focused broadly on the use of prescribed fire and its impacts on fuels management, soil properties and processes, and potential human health considerations, such as water quality and smoke chemistry.

070. Gas-Phase Products from the Pyrolysis of Southeastern Fuels using Open-Path Infrared Spectroscopy

Presenter: Nicole Scharko, Post doctorate, Pacific Northwest National Laboratories
Additional Author(s): Oeck, Ashley, Post bachelors, Pacific Northwest National Laboratories
Danby, Tyler, Post bachelors, Pacific Northwest National Laboratories
Chong, Joey, Physical Science Technician, USDA Forest Service, Pacific Southwest Research Station
Corcoran, Bonni, Biological Technician, USDA Forest Service, Pacific Southwest Research Station
Burke, Gloria, Forestry Technician, USDA Forest Service, Pacific Southwest Research Station
Bernacki, Bruce, Scientist, Pacific Northwest National Laboratories

Wildland fires are becoming more prevalent and more intense each year. Prescribed fires are often used to reduce hazardous fuel buildup and prevent uncontrollable wildland fires. For both wildfire and prescribed burns, distinguishing between the gas-phase products generated during the various phases (pyrolysis, flaming, and smoldering combustion) of the burning process is important for understanding and predicting fire behavior. Although gas-phase combustion products from biomass burning experiments have been studied extensively, less is known about pyrolysis processes and products that occur in the initial stage of the burning process. To address this problem, fifty wind tunnel experiments were carried out at the Riverside Fire Combustion Laboratory (RFL) to detect and quantify pyrolysis products using an open-path FTIR instrument to monitor gas-phase products in a non-disruptive manner. Preliminary results of analytes as a function of time will be presented for burns using fuel beds of longleaf pine needles (Pinus palustris) with fetterbush (Lyonia lucida) and inkberry (Ilex glabra) shrubs. Quantities, such as emission ratios and modified combustion efficiencies, will be presented as a function of time to distinguish between the different phases of the fire. Preliminary measurements confirmed species such as CO_2, CO, CH_4, C_2H_4, HCHO, CH_3OH, and NH_3 being produced by pyrolysis.

Keywords:

Bio: Nicole Scharko is a DePaul University graduate and received her PhD in 2016 from Indiana University studying formation mechanisms for gas-phase reactive nitrogen species using Cavity Enhanced Absorption Spectroscopy (CEAS). She has experiences monitoring surface bound and gas-phase nitrogen species using diffuse reflectance and gas-phase Fourier Infrared Transform Spectroscopy (FTIR). She joined PNNL in November 2016, and she is involved in a project that focuses on collecting and analyzing gas-phase products from biomass burns.

071. Characterization of Pyrolysis Products from Fast Pyrolysis of Live and Dead Vegetation
Presenter: Thomas H. Fletcher, Professor, Brigham Young University
Additional Author(s): Safdari, Mohammad-Saeed, PhD Student, Brigham Young University
Berryhill, Jansen P., undergraduate research assistant, Brigham Young University

Prescribed burning (controlled burning) is one way to destroy smaller plants in order to decrease accumulation of combustible materials and avoid occurrence of uncontrolled wildland fires. U.S. Forest Service plans to apply prescribed fires in Southern and Southeastern forests of the United States. In order to improve prescribed fire application, accomplish desired fire effects, and limit potential escapes, an improved understanding of the fundamental processes related to pyrolysis and ignition in heterogeneous fuel beds of live and dead fuels is needed. During this research, fast pyrolysis of 15 live and dead plants which are native to the Southern and Southeastern United States have been studied using a flat-flame burner (FFB) system. The FFB system enables experiments at a high heating rate (~100 K/s) and moderate temperature (~765°C) to imitate pyrolysis during typical fire spread conditions assuming convective heating only. Fuel-rich conditions in the post-flame gases of the FFB system allowed detailed specification of pyrolysis products using gas chromatography/mass spectrometry (GC-MS) for tars and gas chromatography equipped with a thermal conductivity detector (GC-TCD) for non-condensable gases. Differences between yields of non-condensable gas species were small between plant species. Composition of tars included aromatic species with 1 to 5 rings with very few attachments. The pyrolysis products observed at this temperature appear to have experienced secondary pyrolysis. The tar composition showed some large changes with plant species. Comparison of products from pyrolysis of live vegetation and dead vegetation of the same plant species showed differences in tar, gas, and char yields, but no major changes in the types of compounds observed.

Keywords: pyrolysis, live shrubs

Bio: Dr. Thomas H. Fletcher is a Professor in the Department of Chemical Engineering at Brigham Young University. He has been on the faculty at BYU since 1991, and is currently serving as Department Chair. His research interests include pyrolysis, gasification, and combustion of coal and biomass, fundamentals of wildland fire ignition, soot formation from aromatic compounds. He has coauthored one book, five book chapters, and has over 115 peer-reviewed publications and made over 2350 presentations at technical conferences. He has been the advisor for 19 completed PhD dissertations, 10 MS theses, and currently is advising 6 graduate students.

072. Tar and gas composition from slow pyrolysis of 15 live and dead plant species from the Southeastern United States
Presenter: Elham Amini, PhD Student, Brigham Young University
Additional Author(s): Howarth, Joel, undergraduate research assistant, Brigham Young Univesity
DeYoung, Jonathan, undergraduate research assistant, Brigham Young Univesity
Fletcher, Thomas H., Professor, Brigham Young University

Wildland fire is an important component of Southeastern United States ecosystems, and can have necessary ecological influences in many ecosystems or can dangerously affect life, property and natural resources. Fuel bed ignition and pyrolysis determine fire ignition and propagation rates in wildland fires, but the details of solid fuel reaction under wildland fire conditions remain poorly understood. In order to improve understanding of the fundamental process related to pyrolysis in fuel beds of southeastern United States forests, the slow pyrolysis experiments of 15 live and dead plant species all of which are native to these forests were carried out in a pyrolyzer under nitrogen atmosphere with a low heating rate (~10-30 °C/min), temperature of 500 °C, and sweep gas flowrate of 100 ml/min. The chemical composition of tar and non-condensable gases were studied using gas chromatography-mass spectrometry (GC-MS) and gas chromatograph-thermal conductivity detector (GC-TCD) techniques, respectively. The tar analysis showed that the major compounds were oxygenated aromatic species, which were mainly phenols. The non-condensable gas analysis showed that CO and CO_2 were the dominant compounds for all live and dead plant species on a dry, wt% basis, followed by CH_4 and H_2.

Keywords: Slow pyrolysis, live shrubs, gas and tar composition

Bio: Elham Amini is a 2nd year PhD student in the Chemical Engineering Department at Brigham Young University, working on a SERDP project to characterize the pyrolysis products of live and dead vegetation from the Southeastern United States.

073. Stand dynamics of lodgepole pine forest types, and their influence on historical fire regimes in surrounding ponderosa pine and mixed-conifer forests of the Klamath Basin.

Presenter: Andrew Merschel, PhD Student, Research Ecologist, College of Forestry, Oregon State University
Additional Author(s): Krawchuk Meg, Dr., Oregon State University

Landscape-scale restoration plans are emphasized in fire-suppressed forests across the northwest, but most reconstructions of historical fire regimes are smaller than planning areas. In central Oregon, planning areas are composed of a mosaic of ponderosa pine, mixed-conifer, and less extensive climax lodgepole pine forests. Lodgepole forests occupy environments where topography and soils create conditions that are too cold, too wet, or too variable for other tree species. There are dry, moist, and wet lodgepole types with distinct fuel structure, composition, and productivity. However, there has been no evaluation of how fire regime and stand dynamics vary among types. At larger landscape scales, fire ecologists have little information on how different lodgepole types influence fire spread and frequency. Previous dendrochronological studies in the region suggest relatively fuel-limited lodgepole forest may modify fire regimes by impeding fire spread. Our objectives were to: 1) determine variation in fire regimes and stand dynamics across lodgepole types, 2) determine how lodgepole forest historically influenced fire regimes in the broader landscape, and 3) determine the abundance of stand-replacing fire in lodgepole forest, and document ensuing forest succession.

We used a gridded network of 52 fire history plots to systematically reconstruct surface fires over a 90,000 ha study area in south-central Oregon. Within this landscape we used tree rings to reconstruct fire history and stand development in three large patches (500-1500 ha) of climax lodgepole pine forest. Large fires (>10,000 ha) historically occurred 5-7 times per century, and several fires exceeded the extent of our study area. Therefore, we found no evidence that lodgepole pine forests limited fire spread or modified fires regimes in surrounding forests. Development history of lodgepole forest varied within types and among types. Both dry and moist lodgepole had extensive areas where tree ages varied at fine scales (10s of meters) reflecting frequent disturbance by low- to moderate-severity fire and mountain pine beetle. Wet lodgepole pine environments had relatively few trees that preceded fire exclusion, and represent forest encroachment of meadows. We sampled the largest known historical patch (700 ha) of stand-replacing fire in central Oregon that that occurred in dry and moist lodgepole types. Prior to burning in 1918, this area burned frequently, but 100 years after the fire, conditions reflect a relatively barren ‘pumice desert’. This suggests that fuel-limited pumice deserts, which are a sub type of dry lodgepole, are the result of past stand-replacing fire on coarse pumice soils.

Keywords: Fire regimes, lodgepole pine, fire history, landscape restoration

Bio: Andrew Merschel is a fire ecologist who works with management agencies and forest collaboratives to develop a shared understanding of historical fire regimes and opportunities for forest restoration. Andrew's study areas include ponderosa pine and mixed-conifer forest in the eastern Cascades, lodgepole pine forests on the central Oregon Pumice Plateau, and Douglas-fir forests on the west slope of the Cascades in southern Oregon. Andrew enjoys sanding in his spare time.

074. Fire reconstruction in ponderosa and mixed conifer forests of the Mescalero Apache Tribal Lands (NM)

Presenter: Alicia Azpeleta Tarancon, Research Assistant, NAU
Additional Author(s): Fulé, Pete, PhD, NAU
Sánchez Meador, Andrew, PhD-professor, NAU
Kim, Yeon-Su, PhD-professor, NAU

Few tribes in the Southwest have recognized and reintroduced fire in a frequency similar to the pre-European Settlement times to enhance forest resilience. The Mescalero Apache Tribe, located on the southeastern range of the Sacramento Mountains (NM), currently follows a 100% fire suppression policy, but is interested in understanding the traditional role of fire for forest management. Crossdating fire scarred tree samples is a precise technique to reconstruct historical fire regimes. We reconstructed the fire regime in the ponderosa and mixed conifer forest in the Mescalero Apache Tribal Lands at multiple sites and drew inferences about the landscape-level role of fire since the late 14th century. We related fire frequency and occurrence with climate and human use.
This information is valuable for the tribe to implement the traditional use of fire and it is also relevant for forest managers in the Southwest region to face the rising threats related to climate change.

Keywords: fire, tribal lands, ponderosa pine

Bio: Graduated from Barcelona School of Agricultural Engineering. She has a master's degree in Landscape Architecture and a master's degree in Environmental Management of the Environment. She is currently a Ph.D graduate assistant in the School of Forestry at NAU under Dr. Pete Fule. The first chapter of her dissertation is the reconstruction of fire in ponderosa and mixed conifer forest inside the Mescalero Apache Tribal Land (NM).

075. Stand-Replacing Fire in Historically Frequent-Fire Forests in South-Central Oregon

Presenter: Keala Hagmann, Research Ecologist, Applegate Forestry, LLC
Additional Author(s): Merschel, Andrew, Research Ecologist,Oregon State University
Reilly, Matthew, Postdoctoral Researcher, Humboldt State University

Lingering uncertainty about historical extent, patch size, and landscape context of stand-replacing fire impedes social, political, and management support for restoration of forest conditions more likely to be resilient to natural variability in fire regimes as forests adapt to a warming climate. Debate about historical fire severity in fire-prone landscapes stems from limited availability of primary quantitative observations of historical fire effects. In an extensive 1920-1922 timber inventory, fire effects on forest structure were recorded following fires that burned over 78,900 ha in 1918 under warmer, drier, and windier than normal conditions. These data provide a record of fire effects across multiple forest types early in the history of the land-use changes that so substantially altered the composition and structure of forests and fuels. We quantified patch size of stand-replacing fire by forest type in the 1920-1922 timber inventory. Aerial photos from 1952 validate the record of stand-replacing fire in the timber inventory where exposed patches of pumice soil persisted in areas described as stand-replacing in 1918. Most (75%) of the patches of stand-replacing fire were <40 ha (median 16 ha); of the 20 patches ≥100 ha all but two were located entirely or primarily in lodgepole pine. Tree-ring reconstruction documents five fires of comparable extent between 1795-1871. Early timber inventories and tree-ring reconstruction document widespread distribution of large (>53 cm dbh) ponderosa pine in areas that burned both frequently and in very large fires. As a percentage of area burned, stand-replacing fire effects in 1918 were small relative to contemporary fires. In similar forest types, Landsat-derived, fire-severity maps of 22 contemporary (1985-2010) fires each burned less area (<20,000 ha) and had more stand-replacing fire both as a percentage of area burned (25-30%) and in patches ≥100 ha. Historical ponderosa and mixed conifer forests on this landscape were predominantly open and dominated by large, fire- and drought-tolerant ponderosa pine. Current forests are denser, and large ponderosa pine no longer dominate basal area. Contemporary fire regimes in similar forest types substantially underrepresent the area and frequency of the low-severity component of the historical fire regime. Ecosystem services associated with historical forest conditions and fire behavior are at risk – if not already lost – on frequent-fire landscapes where fire exclusion and selective logging of large fire-resistant trees have converted predominantly open canopy forests with diverse understories to denser, closed canopy forests.

Keywords: historical fire behavior, stand-replacing fire, frequent-fire, ponderosa pine, mixed conifer, historical forest conditions

Bio: With colleagues from several institutions and support from multiple sources, including the Klamath Tribes, Confederated Tribes of Warm Springs, USDA Forest Service Pacific Northwest Research Station, The Oregon Watershed Enhancement Board, The Nature Conservancy, and the Oregon Department of Forestry, Keala Hagmann has applied 90-year-old timber inventories to contemporary management questions. This historical record is particularly relevant given projected increases in drought and fire stress and contributes information critical to resolving contentious debates about historical forest conditions and fire regimes.

076. Early successional conditions in the eastern Washington Cascade Mountains: Contrasting the pre-management and modern-eras.

Presenter: Paul Hessburg, Research Landscape Ecologist, USDA-FS, PNW Research Station & University of Washington
Additional Author(s): Povak, Nicholas, Research Ecologist, USDA-FS, PNW Research Station
Salter, R. Brion, Research Geographer, USDA-FS, PNW Research Station

In forest ecosystems, early-successional habitats result after severe disturbances. Patches of early successional habitat can represent a transition to new forest, or an alternative stable state that can persist for decades to centuries. Historically, high severity fires (HSFs), contributed relatively high levels of post-fire structural complexity and within-patch spatial heterogeneity. Post-fire patterns of understory plant communities were also structurally complex and horizontally diverse, reflecting varied micro-sites.

In recent decades, some wildfires have become uncharacteristically large and severe, and there is growing concern that these newer fires are simplifying and coarsening the grain of the western landscape. Observations suggest a relative absence of surviving tree islands, increased frequency of very large HSF patches, and a lack of post-fire conifer regeneration due to increased distance to seed sources.

Little data exist on the early successional patches of pre-management era landscapes and how this varied by physiographic region and forest type. Here, we compare the area and patch size distributions of pre-management and modern era HSFs within several ecoregions covering more than 4 million acres of the eastern Washington Cascades. For the pre-management era, we use vegetation and seral stage reconstructions from early 20th century aerial photography. For the modern era, we use fire severity reconstructions based on MTBS data from 1985 to 2013. We show a strong trend toward increasing HSF area and patch sizes with modern era wildfires.

Keywords: early seral forests, pre-forest conditions, patch size distributions, high severity fires

Bio: Paul is a Research Landscape Ecologist with the USDA Forest Service, PNW Research Station, where he has worked since 1993. He currently leads a research team to explore climate change effects on forest and nonforest patterns, wildfire resilience mechanisms and their capacity for persistence, fuel succession influences on wildfire behavior, and tool development for multi-scale landscape evaluations. Paul holds a Ph.D. in Botany and Plant Pathology from Oregon State University (1984), and a B.S. in Forestry from the University of Minnesota (1978). In 2017, he received the PNW Research Station and Deputy Chief's Distinguished Scientist awards.

077. Assessing the Work of Wildfires with Post-Fire Landscape Evaluations

Presenter: Miles LeFevre, MSc Student, School of Environmental and Forest Sciences, University of Washington
Additional Author(s): Churchill, Derek, Forest Health Scientist, Washington Department of Natural Resources, Olympia, WA 98504
Jeronimo, Sean, PhD Candidate, School of Environmental and Forest Sciences, University of Washington, Seattle, WA 98195
Hessburg, Paul, Research Landscape Ecologist, USDA Forest Service, Pacific Northwest Research Station, Wenatchee, WA 98801
Cansler, C. Alina, Research Forester, USDA Forest Service, RMRS, Fire, Fuel, and Smoke Science Program, Missoula, MT 59808
Kane, Van, Research Assistant Professor, School of Environmental and Forest Sciences, University of Washington, Seattle, WA 98195
Lutz, James, Assistant Professor, S. J. & Jessie E. Quinney College of Natural Resources, Utah State University, Logan, UT 84322

Wildfires across the western US are modifying the structure and composition of forests at rates far exceeding the footprint of mechanical thinning and prescribed fire treatments. Although the pace and scale of management is increasing, the reality is that wildfire is, and will continue to be, the primary agent affecting vegetation and fuels across forests of the American West. This underscores the need to deliberately incorporate the occurrence and effects of contemporary wildfires into landscape analysis and planning. The "work" of wildfires can be beneficial in terms of reducing fuel loads, enhancing fire resistant species and structure, and creating early-seral habitat. However, many

recent wildfires are creating large high-severity patches in dry forests that were historically dominated by low- and mixed-severity fires. These conditions carry potential risks of elevated fuel loads and shifts in ecosystem states and disturbance regimes. These large fires present managers and collaborative stakeholder groups with the huge challenge of assessing the need for post-fire management and reprioritizing the remaining unburned landscape matrix for green restoration treatments.
We introduce here a framework to quantify and analyze the degree to which wildfires move forest structure and composition towards or away from desired conditions by evaluating wildfire effects relative to historical reference conditions at watershed scales. The landscape evaluation system involves comparison of photo-interpreted pre-fire and post-fire attributes with early twentieth century historical aerial photographs. We use the fires of 2014 and 2015 in North Central Washington as a model system to test this approach; current work is focused in two sub-watersheds on the Colville National Forest that were burned by the large Stickpin Fire in 2015. Within our study area, the Stickpin Fire reduced the amount and patch size of fire-intolerant cover types to levels close to historical conditions. Fire increased the amount and patch sizes of fire-tolerant conifer species, as well as broadleaf species and shrub communities. Fire also created larger patches of early seral and open canopy structure stages, moving the structural conditions closer to historical conditions. However, patches of different structural stages remained overly fragmented post-fire compared to historical conditions, as they were pre-fire. Managers are currently utilizing this information to design landscape prescriptions for both post-fire and green treatments that integrate the work of wildfire with mechanical and prescribed fire.

Keywords: photo interpretation, HRV, wildland fire, ecological patterns, spatial pattern, landscape evaluation.

Bio: Miles LeFevre is a MSc student working with the Forest Restoration and Resilience at Multiple Scales lab in the School of Environmental and Forest Sciences at the University of Washington. Miles's research focuses on providing land managers with accessible tools to inform and implement restoration efforts. His recent projects include using LiDAR to assess forest structure and fuels at the Whiskeytown NRA, Oregon Cave NMP, and Redwood NSP; using historical reference data to inform restoration efforts on the Colville NF; and a joint evaluation of photo interpretive and LiDAR derived data on the Colville NF.

078. The biogeography of fire regimes: a trait-based approach
Presenter: Jens Stevens, , UC Berkeley
Additional Author(s):

Historical fire regimes are often defined based on fire history studies and biophysical models, and they offer reference conditions against which contemporary and future fire regimes can be compared. However, spatial models of historical fire regimes lack an explicit link to resilience because they do not consider the functional traits of predominant species that determine tolerance (i.e. survival) of fire. Different tree species vary along multiple, often-correlated dimensions of fire-tolerance traits. Here I introduce a trait-based approach for spatially explicit modeling of fire regimes based on the adaptive capacity of trees to withstand fire, focusing on two correlated traits of bark thickness and tree height. I specifically ask whether biogeographic variation in these fire-tolerance traits aligns with our understanding of fire regimes based on biophysical models from the LANDFIRE program. Using information on functional traits compiled from the literature, I evaluated the fire-tolerance trait landscape across conifer forests of California and compared the mean trait values within different biophysical fire regime groups. Among 23 conifer species found in California, bark thickness and maximum tree height are significantly positively correlated (r=0.776, P<0.001), with thick-barked and tall species having greater fire tolerance (i.e. survival ability) than thin-barked and shorter species. The community-weighted mean trait value for both bark thickness and tree height were significantly greater in forest stands where prior biophysical modeling studies suggest frequent (<35 year) fire-return intervals (FRI's) (mean bark thickness=1.54 cm, mean tree height = 51.4 m), compared to forests with moderate FRI's (35-200 years, mean thickness = 1.01 cm, mean height = 31.0 m) and forests with infrequent FRI's (>200 years, mean thickness = 0.96 cm, mean height = 31.9 m; all P<0.001). These results indicate that applying functional trait-based analyses across a landscape can yield valuable insight into the resilience of forests to changes in fire frequency and intensity. Furthermore, these continuous traits allow descriptions of fire regimes along a continuum of adaptive capacity rather than arbitrarily defined categories. Such a development would position forest resilience to fire along a trait-based continuum, which could greatly increase our spatial resolution for determining priority forest restoration areas and forecasting future resilience in fire-prone forests.

Keywords: Fire regimes, biogeography, functional traits, bark thickness

Bio: Jens Stevens is a postdoctoral researcher at UC Berkeley. He is interested in how vegetation and climate interact to determine fire regimes, in community and ecosystem level responses to fire severity, and in spatial patterns of forest disturbance.

079. Measuring Suppression: Quantifying Reductions in Burn Probability from Initial Attack

Presenter: Jonathan Reimer, Fire Crew Leader, Parks Canada
Additional Author(s): Thompson, Daniel, PhD, Forest Fire Research Scientist, Natural Resources Canada
Povak, Nicholas, PhD, Ecologist Post-Doc, US Forest Service

Rapid suppression, known as initial attack, is the primary tool land managers use to reduce wildfire risk, due to relatively low costs and high rates of success. The effectiveness and spatial variability of suppression programs on fire occurrence risk has not been quantified. Our research describes a novel technique to measure the impact of initial attack, the most significant phase of suppression, by using spatially-explicit burn probability analysis. It is demonstrated on a study area in Kootenay National Park, the Vermilion Valley, a subalpine region of the Canadian Rocky Mountains. Burn probability maps are generated with and without the influence of suppression using the Burn-P3 model and a probability of containment algorithm.
Results indicate that landscape risk is substantially reduced by initial attack, but at lower levels than IA success rate. An initial attack success rate of 87% reduces mean burn probability by 78% in the study area. Suppression effectiveness shows marked heterogeneity, however, with contiguous areas of mature fuels moderating its impact. Notably, suppression is least effective in the study area's 'intensive' management zone, where natural fire is to be excluded. Quantifying suppression effectiveness allows land managers to objectively compare consequences of fire management strategies in the future.

Keywords:

Bio: Jonathan Reimer is a Canadian wildfire manager, eager to bridge the divide between academic inquiry and on-the-ground decision-making.

080. Modeling Suppression Difficulty: Current and Future Applications

Presenter: Francisco Rodriguez y Silva, , Universidad de Córdoba
Additional Author(s): Thompson, Matthew, PhD, Rocky Mountain Research Station, USDA Forest Service
O'Connor, Christopher, PhD, Rocky Mountain Research Station, USDA Forest Service
Calkin, David, PhD, Rocky Mountain Research Station, USDA Forest Service

In this presentation we focus on decision support tools designed to characterize the difficulty of suppression operations. Such tools can be used to assess prevention and preparedness needs, to forecast likely suppression resource demands and accompanying suppression expenditures, to develop strategic courses of action and plans for mobilization of resources, and to inform tactical deployment decisions of where to send suppression resources or conversely where to avoid sending them. In other words, spatial information on suppression difficulty can support decisions ranging from programmatic budgeting to active incident response. We focus our discussion on a recently developed tool (suppression difficulty index, or SDI) that combines variables related to fire behavior with variables related to suppression operations. We describe lessons learned from real-world applications of the model in Spain and the U.S., along with recent updates to the model intended to enhance its operational relevance. Lastly, we offer ideas and suggestions for future directions in modeling suppression difficulty and integrating results into fire management decision processes.

Keywords:

Bio: Prof. Dr. Fco. Rodríguez y Silva, Universidad de Córdoba, Departamento de Ingeniería Forestal Laboratorio de Defensa contra Incendios Forestales E.T.S.de Ingeniería Agronómica y de Montes Edificio Leonardo da Vinci. Campus de Rabanales

081. The development of the algorithm for the attraction of the adapted technical equipment may be taken as a basis for the creation of the concepts and recommendations for the use of the engineering equipment to douse forest fires in Ukraine.

Presenter: Andrii Vorokhta, , National Ecological Center of Ukraine
Additional Author(s):

According to the National report on technogenic and natural safety performance in Ukraine in 2016, the total area of the forest fund makes about 10,8 millions of hectares, among which 2 millions of hectares are fire dangerous ones. The greatest forest fire that had ever emerged on the territory of Ukraine was the forest fire in Kherson region in August 2007 and Kharkiv region in August 2008. In 2007 in Kherson region the fire destroyed 7356 hectares of forests. The total number of the suppression force, involved in recovery work – 1341 representatives of the fireguard, 110 units of the fire-fighting and 74 support equipment.
A specialized ground service consisting of 263 forest fire stations, having 537 firefighting vehicle, 228 engine-driven pumps, 3 200 forest knapsack tanks, 3 000 radio stations, 588 fire observing stations, among which 390 were metal observation towers, performs a detection and extinguishing of the forest fire within the system of the State Committee for Forestry in Ukraine.
Fire-fighting forest vehicles are functionally not able to perform a range of engineering works. Then there is attracted a special technical equipment meant for this. At present, there does not exist any unified algorithm for the attraction of the adapted technical equipment meant for dousing a forest fire on the territory of Ukraine. The adapted technical equipment lays firebreaks, makes fire lines,

throws soil to the center of the creeping fire, sifts through remains, in other words, performs a complex of the engineering works.
Depending on the works performed, the adapted technical equipment meant to douse a forest fire is divided into the following types: fire-break makers; fire-fighting peat machines; soil-throwers; soil shifters and tractors with pumping units; tractor storage reservoirs; booster units based on all-terrain trucks (tractors); multifunctional fire-fighting complexes (remotely operated units).
A hierarchical method for the classification of the fire-fighting and rescue technique allows distinguishing the categories of technical facilities, depending on the tasks that may be fulfilled. The development of the algorithm for the attraction of the adapted technical equipment may be taken as a basis for the creation of the concepts and recommendations for the use of the engineering equipment to douse forest fires in Ukraine.
A complex use of the adapted fire-fighting forest vehicles, the functional possibilities of which do not allow performing a range of engineering works, provides more effective forests and mires firefighting.

Keywords: Fire-fighting forest vehicles, technical equipment, firefighting

Bio: Andrii graduated from the Lviv State University of Life Safety in 2010 a degree in "Fire Security". During my studies oft-times spoke at conferences on forest fires. After graduating from the University, I see duty in the military of Ukraine in capacity of officer commanding of the Fire Department. During his see duty in the military he was twice awarded commendation for the extinguishing of forest fires near arsenal artillery warehouses. From 2013 Andrii is actively involved in volunteering. At the present time it is engaged in the implementation of alternative heating sources.

082. Assessing aerial firefighting use and the continuum of effectiveness with probabilities of success at nested incident management scales to improve future fire response

Presenter: Keith Stockmann, Acting Senior Project Leader, USDA, Forest Service, National Technology and Development Program
Additional Author(s): Becker, Ryan, Project Leader, USDA Forest Service, NTDP
Holder, Zachary, Fire Management Specialist, USDA, Forest Service, NTDP

The Aerial Firefighting Use and Effectiveness (AFUE) study's mission is to systematically document the utilization and effectiveness of aerial water and wildland fire chemical delivery in support of wildland fire management objectives. AFUE is tasked to develop and implement performance metrics, technologies, and evaluation criteria in which effective tactical and strategic decisions are statistically supported. The AFUE approach shows significant progress from previous studies at addressing suppression methods and aircraft performance and effectiveness This was achieved using ground and aerial firefighters to develop terminology that documents the full set of aerial firefighting objectives and by expanding from single liquid drop event analysis to focus on the contributions that aerial tasks (connected drops) make to meeting campaign/incident management objectives. By comparing the continuum of observed outcomes to planned objectives, effectiveness and probability of success will be assessed for the various suppressant/retardant aircraft roles and configurations. Our data schema represents scales starting with individual drops, extending to aerial tasks, groups of aerial and ground tasks that we call campaigns and for larger fires multiple campaigns comprise incidents. Above this level, we show connections to WFDSS objectives, forest, regional and national policies.

The AFUE approach leverages the evolving computerized interagency decision support systems and anchors to this firefighting management hierarchy. Outputs should help firefighters ordering aircraft, multi-agency coordination committee groups prioritizing orders, and aviation managers strategically contracting their fleets and those reporting to Congress to justify funding. The foundation can support techniques capable of assessing cost-effectiveness and break-even values required to justify aerial resource use in achieving strategic objectives. Although this evolving approach will take several years to execute, a planned schedule of deliverables will help Federal agencies, domestic and international partners develop performance metrics that move towards goals of increasing firefighting effectiveness and public safety, while becoming more cost-effective.

Keywords: Airtanker, Retardant, Aerial Firefighting, Use, Effectiveness, Probability of Success

Bio: Keith Stockmann earned a BA in Economics from Colby College an MS in Wildlife Habitat Conservation and PhD in Applied Wildland Economics, both at the University of Montana. He has been supporting wildland fire management and fire aviation since 2007. He is the lead analyst/economist for the Aerial Firefighting Use and Effectiveness Study at the National Technology and Development Program and is currently serving as the study's Acting Senior Project Leader.

083. Deconstructing Suppression Efforts on Large Wildfires to Quantify Effectiveness

Presenter: Heather Simpson, Ph.D. Student, Centre for Environmental Risk Management of Bushfires, University of Wollongong
Additional Author(s): Bradstock, Ross, Professorial Fellow, Centre for Environmental Risk Management of Bushfires, University of Wollongong
Price, Owen, Senior Research Fellow, Centre for Environmental Risk Management of Bushfires, University of Wollongong

Large wildfires (over 500ha) account for a disproportionate amount of both hectares burned and suppression expenditure; however, the effectiveness of large-fire suppression is incompletely understood. Typically, large-fire suppression research has examined resource usage during the containment period. Such research either focuses on single resource types in a limited geographic extent or examines the sum of the fireline resources assigned to whole fires. This study looks at suppression at an intermediate level, classifying multiple resource types and their usage in disparate suppression activities at the fireline division or sector level. The aim is to provide a basis for the development of an overall assessment of the effectiveness of suppression.
This study systematically partitioned suppression operations into five progressive suppression stages. This permitted an examination of the firefighting strategies that occurred during each stage, the resources that were required to accomplish those strategies, how the resources changed with the suppression stages, and the ways that environmental conditions affected progression through the stages. To define the stages of suppression, we conducted a qualitative document analysis of operational documents that were produced during the suppression of 10 large wildfires from the 2013 and 2014 fire seasons in Victoria, Australia. Records span 156 active suppression days and include Situation Reports, Incident Action/Shift Plans, mapping data, and GIS aircraft tracking data. Existing operational protocols were used as a guide to define five suppression stages: defensive, offensive, containment, mop-up, and patrol. A qualitative descriptive method was used to identify the suppression strategies for each stage. Resource usage by number and type was also quantified using the defined stages at the geographic sector level.
This alternative method of evaluating suppression produced a more complete picture of large-fire suppression efforts. For eight of the ten fires, multiple suppression stages occurred in different

sectors on the same day, emphasising why it is necessary to deconstruct large-fire suppression efforts geographically. Less than 45% of the total resources were used for containment efforts, as defined by the offensive and containment stages. Defensive firefighting accounted for a significant proportion (>12%) of the overall resourcing, while roughly 40% of all fireline resources were tasked to mop-up and patrol. Approximately half of all heavy machinery was assigned post-containment, indicating that there is a whole host of suppression activities that need to be evaluated beyond control line construction.

Keywords:

Bio: Heather Simpson is a Ph.D. Student at the Centre for Environmental Risk Management of Bushfires at the University of Wollongong, Australia. Prior to her Ph.D. studies, she spent 10 seasons working as a wildland firefighter with the British Columbia Wildfire Service. She is conducting research on the operational response to large wildfires.

084. Metolius Research "Not-So-Natural" Area: The Effects of Fire Exclusion for an "Intact" Forest

Presenter: Kayla Johnston, MS Student, Oregon State University
Additional Author(s): Merschel, Andrew, PhD student, Oregon State University
Bailey, John, Professor, Oregon State University

Central Oregon receives abundant dry lightning storms and resultant ignitions annually. Historically, these ignitions regularly burned large expanses including the forests of the Metolius Research Natural Area (MRNA). The MRNA is located 29 km northwest of Sisters, Oregon between the Metolius River and Green Ridge. The MRNA was originally established in 1931 with the primary objective to support a high-quality example of ponderosa pine and mixed conifer forest managed in a way that allows natural processes to predominate, with minimal human intervention. Historically, fire returned to the MRNA on average every 6 years – a frequency critical to maintaining forest stand density, structure, and function. However, due to fire suppression and minimal prescribed fire, the MRNA has over a century of fire deficit – a conflict with the primary objective. Mechanical fuel reduction treatments are heavily restricted in the MRNA, limiting management's abilities to minimize the effects of fire suppression. These management tactics have created novel conditions for the ponderosa pine stands in the MRNA including increased fuel loading of coarse woody debris, high stand density, considerable fire hazard, homogenized spatial patterns, high ingrowth and mortality rates, and significant suppression of trees established during the fire exclusion regime. To respect the main objective of the MRNA, it is necessary to return frequent fire to the area. However, due to increased stand density, increased fuel continuity, and ponderosa pine developing fire resistance at a small size, meeting restoration objectives with only prescribed fire would be difficult, if not impossible. It is recommended that a one-time exception be made to allow mechanical thinning and treatment of surface fuels prior to implementing repetitive prescribed fire, in order to restore stand density, structure, and natural processes. This approach would restore the MRNA to meet its primary objective, while creating conditions that would likely sustain it through an uncertain future of climate change and erratic disturbances.

Keywords: Fire history, tree rings, dendrochronology, stand development, passive management areas, fire exclusion, restoration, maintenance, management

Bio: Kayla Johnston is a MS student studying management & ecology of forests & fire at Oregon State University. She is also a wildland firefighter for the US Forest Service. Kayla plans to continue a career in fire & fuels management post-graduation, aspiring to any job that involves a lot of prescribed fire. Kayla has been an active member and officer for the Student Association for Fire Ecology at the chapter and national levels and has enjoyed networking with students and professionals to promote good fire. In her personal life, she enjoys cooking, reading, rock climbing, and adventures with her dog.

085. BURNOUT: a Rapid Mapping burnt area extraction tool
Presenter: Mathilde Caspard, Engineer, ICube - SERTIT
Additional Author(s): Clandillon, Stephen, Project Manager, ICube - SERTIT
Briant, Julien, Engineer, ICube - SERTIT

"Burnout"© is a burn scar mapping tool which was developed at ICube-SERTIT (Strasbourg, France) within the ESA GSTP ASAPTerra (Advanced SAR and optical Methods for Rapid Mapping) project in order to improve, automate and speed-up geo-information extraction in rapid mapping. The ASAPTerra project itself encompasses work on landslides, floods and fires.
The tool was elaborated to respond to the need of firefighters and the fire management community, including foresters, to receive precise and near real-time information concerning the fire extent and fire severity. A secondary application is systematic burn scar mapping using high resolution imagery in an activity complementary to the European programme Copernicus EMS EFFIS.

The development focuses on free data available at a high spatial resolution from 10m to 30m with repeat cycles between 6 and 16 days. Consequently, "Burnout"© uses USGS's Landsat8 optical imagery and the European Space Agency's Sentinel-2 missions. The concept is to compare pre-event and post-event images in order to extract the burn scars and indicate the severity of the wildland fire. A fully-automatic algorithm based on free Orfeo Toolbox and GDAL libraries allows Burnout to produce a result in a few minutes.

The technical results were evaluated and demonstrated in real case applications and in different environment around the globe including fires in California (USA), France, Greece, Portugal and Spain. Furthermore, validation was conducted by comparing the tool result's with that of the Europe Union's Copernicus Emergency Management Service (EMS) photo-interpretation derived results from very high resolution image sources. It shows a global accuracy above 90%.

This operational tool demonstrates that through new satellites and IT technologies near real-time decision making can be helped during and after a wild-fire. Combined with damage assessment seen on satellite imagery and furthermore in the field, it highlights the environmental consequences and risks induces by these fires.

Finally, this tool merges within the one platform very high spatial and high temporal resolution imagery and could help provide an important resource to whole crisis management cycle.

Keywords: Fire, remote-sensing, Sentinel-2, Lansdat-8, burn scar, severity

Bio: Mathilde Caspard has a geography background, specialized in cartography and in remote-sensing, and MCs in Geosciences, Environment and Risks. During her 10 years' experience in SERTIT, she has treated many R&D as operational projects. Active member of the Rapid Mapping Service, she participates in the International Charter Space and Major Disasters, and COPERNICUS EMS actions in order to deliver as fast as possible event-related geo-information to users. She's a key member of

SERTIT for fires studies, with a strong implication in European projects where she has developed applications for burn scar detection and post-fire soil erosion risk.

086. Mapping Canadian Interface Areas
Presenter: Lynn Johnston, Forest Fire Research Specialist, Natural Resources Canada
Additional Author(s): Flannigan, Mike, Professor, University of Alberta

This presentation will cover recent work on mapping the Canadian wildland-urban interface (WUI). We will also discuss future research efforts continuing from this study: risk mapping in the interface, interface change detection, and climate change impacts in the interface. Prior to this study, no national map of the WUI was available in Canada. We also extended the interface concept beyond the traditional "urban" structures of the wildland-urban interface to include industrial structures (e.g. oil and gas structures) or infrastructure values (e.g. roads, powerlines, railways); producing two additional national maps to reflect the interface areas of these potentially vulnerable industrial structures (i.e. the wildland-industrial interface) or infrastructure values (i.e. the wildland-infrastructure interface) with wildland fuels. The interface maps provide a baseline for future work but also have a variety of practical applications such as: fire management planning and decision support, insurance, municipal planning, and fire mitigation.

Keywords: communities, fuels, values, risk, wildland–industrial interface, wildland–infrastructure interface, wildland–urban interface

Bio: Lynn Johnston is a Forest Fire Research Specialist with Natural Resources Canada. She works out of the Great Lakes Forestry Centre in Sault Ste. Marie, Ontario. She recently obtained her MSc. from the University of Alberta.

087. Hyperspatial Mapping of Post-fire Effects Using Artificial Intelligence
Presenter: Dale Hamilton, Assistant Professor of Computer Science, Northwest Nazarene University
Additional Author(s):

Small unmanned aircraft systems (sUAS) provide affordable, on-demand monitoring of wildland fire effects at a much finer spatial resolution than is possible with the current approaches using satellites or manned aircraft. Approaches examined for improving the extraction of post-fire effects knowledge from hyperspatial (sub-decimeter resolution) imagery acquired with a sUAS include:
1. Demonstrating that indicators of burn severity were mapped more accurately from hyperspatial than 30 meter color imagery.
2. Demonstrating that with the addition of image texture metrics to color as a fourth hyperspatial input to machine learning algorithms, burn severity classes of interest were mapped more accurately.
3. Demonstrating that wildland fire effects were mapped with higher accuracy using Support Vector Machines than was achieved with k-Nearest Neighbor classifiers when mapping wildland burn severity classes using hyperspatial color imagery.

Each of these three approaches resulted in an increase of accuracy by which post-fire effects were mapped from a set of orthomosaics acquired with a sUAS over a variety of wildland fires. Development of tools, methods and metrics which utilize hyperspatial sUAS multi-spectral imagery enable managers to monitor fire effects at a much finer resolution than is possible with current technology, providing new knowledge to assist with post-fire ecosystem management. This information will allow for the realization of optimized management and decreased associated costs leading to improved data-driven land management decisions resulting rapid post-fire recovery and effective use of resources.

Keywords: sUAS, Burn Severity, Remote Sensing, Artificial Intelligence

Bio: Dale Hamilton joined the Math and Computer Science Department at Northwest Nazarene University (NNU) as an Assistant Professor of Computer Science in August, 2013. Dale graduated with a PhD in Computer Science at the University of Idaho in May, 2018. His research includes development of analytics for mapping wildland fire severity and extent from hyperspatial unmanned aircraft system imagery. Dale has been awarded multiple NASA grants in support this research effort. Prior to coming to NNU, Dale spent 13 years writing software modeling fire behavior and effects, ecological departure and remote sensing under contracts with the USDA Forest Service.

088. sUAS Based Post-fire Remote Sensing Lessons Learned: Southwestern Idaho Fire Season 2017
Presenter: Nicholas Hamilton, Student (Computer Science), Northwest Nazarene University
Additional Author(s): Hamilton, Dale, Assistant Professor of Computer Science, Northwest Nazarene University

Sensor miniaturization and sUAS offer a new paradigm, providing affordable, on-demand monitoring of wildland fire effects at a much finer spatial resolution than is possible with satellite or manned aircraft, providing finer detail at a much lower cost. This increased resolution contains post-fire effects information that has not been previously detectable, such as white ash and individual unburned plants. sUAS imagery was acquired over 16 fires across southwestern Idaho during the 2017 fire season. The presentation is a discussion of the procedures developed and lessons learned during that effort.

Keywords: sUAS, Burn Severity, Remote Sensing

Bio: Nicholas Hamilton is a senior computer science major at Northwest Nazarene University who has worked as an undergraduate researcher on NNU's FireMAP project for the past four summers. Nicholas assists with development of the artificial intelligence based analytics which enable the extraction of post-fire effects knowledge from hyperspatial drone imagery.

089. LiveTexture: Realtime photogrammetry and Earth texture mapping from crowd-sourced mobile phones and social media
Presenter: Stephen Guerin, CEO, SimTable
Additional Author(s):

We are currently managing incidents and long term forest health blindly. There is a potential to georectify and stitch together crowd-sourced imagery from social media, mobile phone, drones, forest cams and air operations into realtime 30 frame-per-second 3D pointclouds for situational awareness for responders and citizens. Simtable will review their work on LiveTexture development with live demonstrations requiring only phone browsers for imagery capture, computational processing, data distribution (no servers), pointcloud visualization and measurement. These 3D models can further be used to empirically calibrate emerging convective models of plume-dominated fires. Techniques also have ecological applications for fuels monitoring and fire effects at high temporal and spatial fidelities.

Keywords: Realtime Photogrammetry, Crowd-Sourced Situational Awareness, Social Media, Wildfire Model Validation

Bio: Stephen is the inventor and founder of the Simtable - a physical sandtable augmented with projected interactive spatial GIS simulations and data feeds. He researches self-organizing design methods and serves on Faculty at Santa Fe Institute Complex Systems Summer School lecturing on agent-based models and complex systems visualization. Stephen is an external researcher at San Diego State University's Visualization Lab led by Dr. Eric Frost. Buy him an IPA in Missoula and he'll ramble on about the connection of least action principles regulating chemical fields between mitochondria and chloroblasts of an autotrophic plant cell and equivalent least action principles in ecological forest structure regulating interaction pathways between photosynthesis and wildland fire combustion.

091. Effects of fire severity on understory diversity in the Sierra Nevada, California

Presenter: Clark Richter, PhD Candidate, University of California - Davis
Additional Author(s): Rejmanek, Marcel, Professor, University of California - Davis
Safford, Hugh, Region 5 Ecologist, USDA Forest Service

A major disturbance like wildfire can reshape the ecological characteristics of a system, but the magnitude of ecological effects it imposes are not necessarily homogeneous across its post-fire landscape. Within a post-wildfire perimeter, understory plant communities may regenerate across a spectrum of disturbance severity classes. Wildfire patterns in the Sierra Nevada have changed from historic regimes as high severity post-fire sites are more frequent and larger in area. Such high severity sites are known to impose environmental characteristics suitable for only a small number of species. For many land management agencies working in wildfire-prone ecosystems, the recovery of biodiversity in a site is often a priority. In the Sierra Nevada and other temperate forest ecosystems, understory plant species contribute significantly to overall community diversity, thus understanding how understory plant diversity varies in response to novel fire regimes is imperative. However, despite existing research showing understory diversity is greater in sites managed for low to moderate wildfire, there remains a gap in our understanding of post-fire diversity in mixed-conifer, unmanaged sites in the Sierra Nevada. We conducted complete understory plant censuses of plots across a spectrum of fire severity classes in eight wildfire perimeters of varying age to examine patterns in understory diversity. We found evidence that high severity fire is driving a homogenization of understory plant communities, but there is still high diversity in moderate severity sites. We also found that understory communities in sites greater than low severity are likely to increase in dissimilarity from unburned controls over time, suggesting that homogenized understory communities may persist for decades after burning. There is a strong possibility that lower biodiversity will become more common with more frequent high severity wildfire, but questions still remain about how long these communities may persist.

Keywords: fire, diversity, understory, plants, severity

Bio: Clark is currently a PhD candidate at the University of California - Davis working with Marcel Rejmanek and Hugh Safford. He completed his Master's research on plant response to large mammalian herbivores at Sonoma State University. He served in the Peace Corps as a coastal resource management and environmental education volunteer after completing his undergraduate degree from Albion College in Michigan. He lives in the Bay Area.

092. Heterogeneity in fire severity benefits post-fire plant diversity
Presenter: Jesse Miller, Postdoctoral researcher, University of California, Davis
Additional Author(s): Safford, Hugh, Ph.D., Regional Ecologist, US Forest Service Region 5

Understanding the effects of wildfire on biodiversity is crucial for planning pre- and post-fire management activities. Herbaceous plant communities play important roles in forest ecosystems but their responses to wildland fire remain incompletely understood. Previous research on how fire affects understory plant communities has focused largely on prescribed fires, which often do not represent the full range of fire severity that characterizes wildfires. In addition, previous research on fire effects on plant communities has generally focused on small geographic areas (e.g., a single fire), making it difficult to identify generalizable patterns across ecological gradients. Pyrodiversity—or spatial heterogeneity in fire history—may be one important driver of post-fire plant communities, but its effects have rarely been studied for plants. To understand the relative effects of local fire severity and heterogeneity of fire severity in the surrounding landscape on plant communities, we sampled plant communities in ~250 study plots across eight different wildfires in the Sierra Nevada and Warner Mountains of California. We used remotely sensed fire severity data to characterize spatial heterogeneity in fire severity within 100 m of study plots (hereafter pyrodiversity). Pyrodiversity had a positive effect on plant diversity, and in some cases was a stronger predictor of plant species richness than local fire severity. These findings indicate that fires that burn at heterogeneous severity may benefit plant diversity. The increasing prevalence of large, homogenous, high-severity burn patches, however, may eliminate fire-sensitive species from the landscape. Our findings suggest that pre-fire management that leads to heterogeneous burn mosaics is likely to benefit plant diversity and, potentially, the higher trophic levels that plants support.

Keywords: pyrodiversity, plant community, understory, fire severity, heterogeneity, fire regimes

Bio: Jesse Miller is a postdoctoral researcher at UC Davis whose research emphasizes the relative influences of disturbance, landscape context, and local environment on plant and lichen communities. Jesse recently published a paper showing that both plant diversity and fire history simultaneously influence grasshopper diversity in Midwestern grasslands. Jesse's work lies at the confluence of basic and applied ecology, and he greatly enjoys interacting with practitioners and conducting research that informs management practices.

093. Restoration Treatment Effects on Fire Severity and Post-fire Vegetation Recovery
Presenter: David Peterson, Research Forester, USDA Forest Service, PNW Research Station
Additional Author(s): Prichard, Susan, Research Scientist, University of Washington

Dry forest restoration treatments have been applied in dry coniferous forests of western North America to improve forest health and make forests more resilient to fire in a warming climate. Recent studies have demonstrated that restoration treatments, particularly those that involved prescribed burning, have been effective at mitigating wildfire behavior and effects. However, there are almost certainly fire weather thresholds beyond which restoration treatments are rendered ineffective. Beyond greater tree survival, restoration treatments may improve post-fire soil stability and recovery of understory vegetation by facilitating the establishment and persistence of fire-tolerant woody and herbaceous plant species that can rapidly re-sprout following fire, provide soil cover, and compete with exotic plant species. The 2014 Carlton Complex was the largest wildfire event in Washington State history, and much of the fire area burned under extreme weather conditions with explosive fire growth. Because the Carlton Complex burned over many recent fuel treatments, it offered an opportunity to evaluate if and how restoration treatments mitigated fire severity in this extreme wildfire event. Here, we report results from a three year research project investigating restoration treatments effects on fire severity during the Carlton Fire and the combined effects of restoration treatments and fire severity on post-fire understory vegetation cover and biodiversity.

Keywords: Restoration; mechanical thinning; prescribed fire; biodiversity; vegetation recovery

Bio: Dave W. Peterson is a Research Forester with the U.S.D.A. Forest Service, Pacific Northwest Research Station, located in Wenatchee, Washington. Dave's research focuses primarily on restoration and management of dry coniferous forests, including forest ecosystem responses to wildfires, the effects of post-fire management practices, and vegetation responses to fuel management treatments. He also maintains ongoing research interests in oak savanna ecology and dendroecology.

094. Initial Response of Plant Community Composition to Fire Severity in Andean Araucaria-Nothofagus Forests, Chile

Presenter: Fuentes-Ramirez Andres, Researcher, Department of Forest Sciences, Universidad de La Frontera, Temuco, Chile
Additional Author(s): Salas-Eljatib, Christian, PhD, Laboratory of Biometrics, Department of Forest Sciences, Universidad de La Frontera, Temuco, Chile
González, Mauro, PhD, Instituto de Conservación, Biodiversidad y Territorio, Universidad Austral de Chile, Casilla 567, Valdivia, Chile, Centro de Ciencia del Clima y la Resiliencia (CR)2
Arroyo, Paola, MS, Laboratory of Biometrics, Department of Forest Sciences, Universidad de La Frontera, Temuco, Chile
Urrutia, Jonathan, MS, Laboratory of Biometrics, Department of Forest Sciences, Universidad de La Frontera, Temuco, Chile

Over the last 15-20 years, an increasingly number of wildfires have affected old-growth Araucaria araucana forests in the Andean region of south-central Chile (36-41°S). The native conifer Araucaria araucana is adapted to fire, but the effect of high-severity fires on the forest understory remains unclear. In this study we seek to answer (1) What is the short-term response of Araucaria forests to a severe wildfire over?; and (2) Do plant diversity, abundance of dominant tree species, and spatial distribution of vegetation exhibit different patterns across a fire severity gradient?

We studied a burn gradient ranging from areas of high fire severity to unburned areas in Araucaria araucana-Nothofagus pumilio forests in the Andes of south-central Chile, and sampled vegetation recovery one year after fire, during Jan-Mar 2016. We measured species richness, abundance, plant height, and pant origin (native vs. exotic species). We also analyzed the spatial pattern of plant recovery.

One year after fire, species richness, abundance and plant height were significantly higher within unburned forest and low fire-severity areas, compared areas of high and moderate severity. We found >50% of species exclusion in areas severely affected by fire (including the dominant tree Nothofagus pumilio). Only six species (12% of total richness) were common across the entire burn gradient.

Plant diversity and abundance of A. araucana and N. pumilio were greatly reduced within high fire-severity areas. Exotic species were more abundant within unburned areas, suggesting that their establishment was not directly mediated by fire, but through other disturbances such as cattle grazing. Our research highlights the potential change in forest structure if dominant tree species are not capable to recover after severe fires, which ultimately depend on the successful recovery of A. araucana, the arrival of propagules that can promote N. pumilio establishment, and further disturbances in the near future.

Keywords: fire ecology, burn gradient, post-fire vegetation recovery, restoration, temperate forests, fire regimes

Bio: Dr. Fuentes-Ramirez is a young scientist, who received his PhD at Iowa State University in 2015, and he's interested in the positive feedback between plant invasions and the alteration of fire regimes. Back in his home country, Chile, his research is focused on the ecological impacts of severe wildfires on patrimonial Araucaria araucana forests, and how ecosystem variables such as, plant community composition and soil properties respond to fire severity over time. To accomplish this, Dr. Fuentes-Ramirez uses a suite of different approaches, including field experiments, observational studies and simulation & modelling tools.

095. Population Dynamics within Relict Stands of a Fire-dependent Cypress Following a Large Scale Wildfire Event.

Presenter: Teresa Brennan-Kane, Ecologist, United States Geological Survey
Additional Author(s): Keeley, Jon E., Research Scientist, United States Geological Survey

Tecate cypress (Hesperocyparis forbesii) is a rare, endemic species restricted to four populations in southern California and a few isolated populations in northern Baja California. This species is fire-dependent with an estimated natural fire frequency of 50 to 100 years. Over the last century however the average interval between fires in these populations has dropped to 25 years. The largest population of Tecate cypress occurs on Otay Mountain in San Diego County, California and has a range of stand ages due to the high frequency of wildfires in the area. In 2003 the 18,733 hectare Otay Fire burned through nearly the entire population of Tecate cypress on Otay Mountain and provided an opportunity to study the population dynamics of this species. Our study objectives were to evaluate the effect of burn severity, prefire stand demographics, and environmental characteristics on postfire seedling recruitment and to assess changes in density and tree maturity over a 14 year period. Data were collected in 16 randomly chosen plots across Otay Mountain in postfire years 1, 2, 6, 8, 11, and 14. No significant relationships were observed between postfire recruitment and fire severity, prefire stand density, or a number of environmental characteristics including elevation, incline, insolation, rock cover, or various soil characteristics. Seedling recruitment was however related to prefire stand age ($R2 = 0.35$, $P < 0.05$) and the oldest plots that were 53 years old at the time of the fire had a significantly higher recruitment of seedlings than plots that were 7, 22, 33, and 42 years old ($F4,11 = 7.54$, $P = 0.004$). No recruitment was observed in plots that were seven years old prior to the fire. The average mortality rate of cypress in plots over the 14 year period was 75%, which was a decrease in density from 34,500 trees per hectare in year one to 8,700 trees per hectare in year fourteen. The first cones were observed in year eight on less than 1% of trees; however by year fourteen 39% of trees had an average of 10 cones each. While this species is reasonably quick to mature these findings suggest that a shortened fire-return interval in these systems has the potential to threaten the persistence of individual stands and in extreme cases could lead to the loss of an entire population.

Keywords:

Bio: Teresa Brennan-Kane is an ecologist with the United States Geological Survey at the Sequoia and Kings Canyon Field Station in Three Rivers, CA. Her field of study is fire ecology in the chaparral dominated landscapes of Southern California with recent publications assessing the effectiveness of fuels treatments and defensible space in these highly flammable systems.

096. A New Process for Quantifying Post Fire Recovery of Rangeland Production
Presenter: Matt Reeves, Research Ecologist, USDA, Forest Service, Rocky Mountain Research Station
Additional Author(s):

Recovery of production after a wildfire event is essential for maintaining goods and services such as providing forage on a sustainable basis. Often general rules of thumb, such as waiting two years after a fire to return to pre-fire grazing intensity, are used for managing production of livestock on rangeland landscapes. New research suggests that delaying grazing after wildfire may not be needed but this depends strongly on the vegetation and climate being considered. In addition, quantitative guidelines indicating the length of time required for vegetation to return to pre-fire production levels are lacking for many vegetation types. Here we quantify the recovery periods for 23 vegetation types in the Intermountain region of the western United States. Here we describe development of an analysis procedure that uses MODIS 250 m NDVI to evaluate production recovery and quantifies the length of time needed until no significant difference between burned and unburned landscapes is observed. Our results demonstrate great variability in recovery periods and permit development of new resting guidelines for numerous vegetation types across the extent of coterminous US rangelands.

Keywords: Rangelands, production, MODIS, Recovery

Bio: Dr. Reeves is a Research Ecologist with the Human Dimensions Program at Rocky Mountain Research Station. He specializes in use of remote sensing and GIS to facilitate evaluation of contemporary issues facing US rangelands. His research portfolio consists of a variety of subjects spanning 4 disciplines including climate change, decision support tools, inventory and monitoring, and threat assessment.

097. Effects of different prescribed fire ignition techniques on fire behavior
Presenter: Alex Jonko, Postdoctoral Researcher, Los Alamos National Laboratory
Additional Author(s): Linn, Rodman, Senior Scientist, Los Alamos National Laboratory
Winterkamp, Judith, Research Scientist, Los Alamos National Laboratory
Williams, Brett, Eglin Wildland Support Module Lead, Eglin AFB
Furman, James, U.S. Forest Service Liason, Air Force Wildland Fire Branch

Prescribed fire is an important forest management tool, used for hazard reduction by reducing fuel buildup and decreasing the likelihood of more intense wildfires, as well as ecosystem and wildlife habitat management.

Simulation of prescribed fires, in turn, is a valuable tool for prescribed fire practitioners in their decision making. The tools currently used for this purpose are operational fire behavior models, which do not include fire-atmosphere interactions, or interactions between multiple fires, which are

important for prescribed fire practitioners to understand. Here we use a process-based, computations fluid dynamics wildfire model, FIRETEC, to investigate the impacts of different prescribed fire ignition techniques on fire behavior, and on fire-atmosphere interactions.

We compare strip ignition and aerial point source ignition in a flat 500 m by 1200 m domain with surface, midstory and canopy fuels, typical of a longleaf pine ecosystem, and for two ambient winds speeds; 5mph and 12mph. We investigate differences in total consumption and fire intensity, as well as the effect of both types of ignition on the ambient wind field and its interactions with the fire. Especially at high wind speeds, we observe that the strip ignition, which ignites a continuous line, as opposed to points separated from each other, burns more intensely, producing stronger up and downdrafts within and above the fire, as well as larger zones of smoke emission.

Keywords: prescribed fire, fire-atmosphere interactions, process-based fire model, FIRETEC

Bio: Alex Jonko is a postdoctoral researcher at Los Alamos National Laboratory, where she works with FIRETEC to study fire behavior and its response to complex topography, as well as different prescribed fire strategies. Alex made the switch to studying wildfire later in life, after a PhD and two postdocs in climate science and modeling. One day, she hopes to combine her expertise in climate and wildfire modeling to improve the representation of fire disturbance in earth system models, as well as our understanding of how climate change might alter fire behavior in the future.

098. Adjusting wildland fire simulations remotely through satellite active fire data: A near real-time approach

Presenter: Cardil Adrián, Researcher, Technosylva inc
Additional Author(s): Ramirez, Joaquin, PhD, Principal Consultant, Technosylva
Monedero, Santiago, PhD, Researcher, Technosylva
Jones, David, Msc, Fire behavior analyst, Technosylva

Large and intense wildfires burn millions of hectares annually, impacting societies worldwide. Environmental, social, and economic impacts can reach catastrophic levels, particularly where human populations interact closely with natural and managed landscapes in fire prone areas. Estimates of wildfire spread near real-time can provide critically important information to firefighters, supporting operational decisions as conditions change. Fire simulation and modeling provides an analytical scheme to characterize and predict fire behavior and spread across the landscape. However, accurately predicting fire spread is challenging given modeling uncertainties, limitations, and assumptions, and local calibration of fire spread models is often required to generate useful results. Satellite active fire data provides a cost-effective way to globally acquire fire spread location information, and allows analysts to adjust fire spread models based on these remotely sensed data. This presentation will discuss the use of VIIRS satellite data to adjust fire simulations using Wildfire Analyst (WFA) in real-time. The method automatically determines fire spread adjustment factors for each fuel model to minimize the arrival time error between the simulated fire and a set of satellite control points where the arrival time of the detected fire is known. Despite some limitations of satellite active fire data to detect and monitor fires, two case studies in Spain and US illustrate positive results in reducing error and fitting the simulated fire growth to the actual fire spread; allowing more accurate fire spread simulations during subsequent burning periods. Opportunities exist to improve real-time calibration of fire spread models by expanding sources of fire location information to include other satellite active fire data (e.g., MODIS, Landsat, et al.), aerial photography and interpreted products (e.g., NIROPS), unmanned aerial systems (UAS), and GPS locations from suppression resources.

Keywords:

Bio: Dr. Adrián Cardil, is a researcher who has been developing several methodologies to assess the effects of extreme weather conditions on large wildland fires in South Europe. His past work has translated already on 20 articles published in journals of international impact, 11 of them as first author. Dr. Adrián Cardil has participated with oral presentations and posters, and on several times granted by research committees to do, in international conferences across Europe, Canada and United States. Dr. Adrián Cardil got excellent marks in his Bachelor degree in Forestry, Master degree in Forestry (with honors) and PhD in Forestry and Fire science (excellent cum laude). He is lecturer in the Fire Master (Master FUEGO) at the University of Lleida, Córdoba and León (Spain) about fire simulation and analysis, and he has been invited to teach on seminars in Italy and Germany. He participated in international mobility programs and International Projects, and has a track on collaborating with foreign researchers.

099. Simulating megafires in Europe as a tool to define management strategies
Presenter: Marc Castellnou, , Catalan Fire and Rescue Service and Pau Costa Foundation
Additional Author(s): Vendrell, Jordi, Pau Costa Foundation
Adrian Candil, Technosylva
Botella, M.Angel, Vaersa

The large wildfires (or megafires) from recent years are showing a continuous increase on fire front intensity, speed of propagation and the capacity to develop convective behavior, e.g. transitioning from pyrocumulus to pyrocumulonimbus. The recent wildfires in Portugal (June and October of 2017) developed pyrocumulonimbus at an unprecedented scale in Europe. The socio-economic changes in the landscape during the last 1000 years should be analyzed in order to understand this wildfire behavior. Agricultural landscapes in very productive soils do no longer exist, and instead there are homogeneous forest masses. Additionally, the consequences of climate change are greater in those regions with a wet winter, that suddenly changes to a long, dry and hot summer.
Combining the lessons learned from Portugal and other Atlantic fires we have extrapolated the potential megafires in Europe using Wildfire Analyst. The output is a 10-year vision of potential megafires in Europe that helps designing the emergency scenarios to face in the near future. Overall this analysis can be used as a tool to help defining the management strategy to face megafires in Europe. We focus on overpopulated areas such as Black Forest, Ardennes, Norway and the Pyrenees.

Keywords: climate change, fire behavior, pyrocumulonimbus, scenarios, Black Forest, Ardennes, Norway, Pyrenees

Bio: Chief fire officer of the Catalan Fire and Rescue Service and President of the Board of Trustees of Pau Costa Foundation

100. Faster Rate of Fire Spread Algorithm Does Not Fundamentally Change the Relative Unimportance of Fuel Treatment for Limiting Simulated Wildfire Area in South-eastern Australia

Presenter: Geoff Cary, Associate Professor, Fenner School of Environment and Society, The Australian National University
Additional Author(s): Davies, Ian, PhD, Visiting Fellow, Fenner School of Environment and Society, The Australian National University

Understanding effectiveness of prescribed burning for limiting unplanned fire is central to wildland fire management worldwide. Insights have been derived from simulation experiments exploring the relative importance of fuel treatment, ignition management and weather for total wildfire area. These findings could be highly sensitive to assumptions about key model mechanisms like rate of fire spread. For example, earlier simulation investigations of fuel treatment effectiveness in FIRESCAPE implemented in south eastern Australia invoked McArthur's Mark V Forest Fire Danger Meter rate of fire spread. However, it has been shown this model under-predicts rate of spread of experimental summer fires by a factor of two-to-three, and the Dry Eucalypt Forest Fire Model (DEFFM) rate of spread model of Cheney and others is recommended. We explored the effect of these differences in rates of fire spread on wildfire area in a computer simulation design incorporating fuel treatment rate (varying from 0–30% of landscape treated), ignition management effort (varying from zero to 75% of ignitions prevented or extinguished) and inter-annual weather variation (included by 10 distinct years of daily weather representative of observed inter-annual variation). Overall, our objective was to determine whether earlier simulation experiments based on McArthur's rate of spread, and the resultant conclusion that fuel treatment is relatively unimportant in determining wildfire area, remain valid or should be revised in light of the newer, faster rate of spread models. On average, over thirty times more area was burned by the FIRESCAPE model incorporating a representation of the faster DEFFM rate of fire spread compared to the otherwise identical model incorporating McArthur's rate of fire spread. Nevertheless, irrespective of this difference, weather and ignition management effort was consistently more important than fuel treatment rate in determining total simulated wildfire area in each case. Fuel treatment effectiveness almost doubled and ignition management effects almost halved in the DEFFM representation, although this was not nearly enough to change the overall rank order of importance of factors determining simulated wildfire area. This improvement in fuel treatment effectiveness was expected to some extent because the vastly greater area burned in the DEFFM representation of the model greatly increases encounter rates between simulated wildfires and areas of simulated fuel treatment. Overall, the results show that our understanding of relative importance of factors determining wildfire area in landscapes does not fundamentally change as a function of modelling with very different rate of spread algorithms.

Keywords: Wildfire, Simulation, Prescribed burning, Fuel treatment, Ignition, Weather, Fire Spread Algorithm

Bio: Geoff Cary is Associate Professor in wildland fire (bushfire) science in the Fenner School of Environment and Society at the Australian National University (ANU). He received a Bachelor of Applied Science (Environmental Biology) (Honours) from the University of Technology, Sydney, and a PhD from ANU for research on landscape fire modelling. Geoff's research interests include: evaluating fire management and climate change impacts on fire regimes using landscape-scale simulation; ecological investigation of interactions between fire and biota from genes to communities; empirical analysis of house loss in wildland fire; and laboratory experimentation of fire behaviour. Geoff specialises in teaching bushfire dynamics and management at ANU, including convening 'Fire in the Environment', co-convening 'Weather, Climate and Fire', and contributing to a range of other courses. Geoff is a member of the Editorial Advisory Committee and an Associate Editor of the International Journal of Wildland Fire, and received the journal's Outstanding Associate Editor Award for 2016. He is a member of the International Association of Wildland Fire and has served on the NSW Parks and Wildlife Advisory Council. He managed the PhD and MPhil program in the Fenner School, ANU, as Associate Director for Higher Degree Research in 2010 and 2011.

101. Overview of FlamMap6 Geospatial Modelling Capabilities
Presenter: Charles McHugh, Fire Spatial Analyst, USFS, RMRS, Fire Sciences Laboratory
Additional Author(s):

The FlamMap fire mapping and analysis system is a standalone PC-based program that runs in a Windows Operating System. FlamMap describes potential fire behavior for constant environmental conditions (weather and fuel moisture) and has been in use since 2002. BASIC Fire behavior is calculated for each pixel within the landscape file independently. Additionally, FlamMap can calculate Burn Probabilities and Minimum Travel Time (MTT) Perimeters based on either random ignitions or a user supplied ignition file to determine conditional burn probabilities across a given landscape under a constant set of fuels, wind and weather conditions. Gridded winds from the WindNinja program can also be used in all simulations. A variety of raster and vector based outputs are produced which can be easily incorporated into standard GIS programs. FlamMap also produces outputs in a KMZ format for use in GoogleEarth. With the release of FlamMap6 FARSITE has been included allowing for the spatial and temporal growth of fires across a landscape based on user supplied temporally variable weather information as well as gridded winds. Additionally, the program now has a landscape editing function allowing the user to make basic edits to landscape data themes within the program. This presentation will provide an overview of these new capabilities within FlamMap6.

Keywords: Fire Modeling, Geospatial Fire Modelling, Fuels Treatment Assessments

Bio: Chuck currently works as a Fire Spatial Analyst at the Rocky Mountain Research Station, Fire Sciences Lab Missoula, Montana in the Fire, Fuel and Smoke Science Program. Current research involves spatial data analysis, 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, and FlamMap 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). During fire season, he operates as a Long-term Fire Analyst (LTAN) in support of wildland fire management at the national, regional, and local levels working with Type-1 and Type-2 Incident Management Teams.

Chuck received his M.S. degree in Forestry from Northern Arizona University in 2001, his B.S. degree in Forestry from Utah State University in 1985, and an A.S. degree in Forest Technology from Mt. Hood Community College in 1982.

102. Automatic assessment of fire propagation nodes for optimizing fuel treatments and improving suppression strategies and tactics

Presenter: Adrián Cardil, , Technosylva inc
Additional Author(s): Quilez, Raúl, PhD, Fire Officer, Consorcio de bomberos de Valencia (Spain)
Monedero, Santiago, PhD, Researcher, Technosylva
Cardil, Adrián, PhD, Researcher, Technosylva

Despite fire is an essential renewing contributor of the ecological cycle in many ecosystems, intense and large wildfires are a major source of forest disruption in fire prone areas worldwide. Environmental, social, and economic impacts can reach catastrophic levels, particularly when fire affects population in the wildland urban interface. Efficient fire control is one of the most challenging and important problems of fire agencies, especially under a climate change context in areas where fuel continuity and load is very high. Based on the minimum travel time fire spread algorithm implemented in Wildfire Analyst software, we present a methodology to identify fire propagation nodes (small patches on the landscape that support fire spread) in order to better allocate fire suppression actions and fuel treatments, minimizing the potential size of fires. The outcomes of our approach are shown by using an example in the Mediterranean (Valencia, Spain). After analyzing the historical synoptic weather conditions, we used 50 random ignition points to run probabilistic fire simulations (100 fire simulations for each ignition point) under an adverse weather scenario. We computed the number of times that the minimum travel time paths reached each 30 m resolution cell on the study area using a logarithmic function to get a relative result. The fire propagation nodes represented the union among all the relevant minimum travel time paths of all fire simulations. Allocating the fuel treatments in the fire propagation nodes, the managed area through prescribed burning, selecting harvesting, silvicultural treatments and others methods was reduced up to 6 %.

Keywords:

Bio: Principal Consultant at Technosylva, providing sophisticated fire behavior analysis and management software for wildland fire. Joaquin as a Professor at the University of Leon, teaches the first class on Geotechnologies and Wildfire at the MsC in Wildfires www.masterfuegoforestal.es. He has a long experience as wildfire software architect in Europe and North America, and is the chief designer of the Wildfire Analyst™ and fiResponse™ products.

103. Wildfire evacuations of First Nations across Canada

Presenter: Tara McGee, Professor, University of Alberta
Additional Author(s): Christianson, Amy, Fire Social Scientist, Canadian Forest Service

The First Nations Wildfire Evacuation Partnership was developed to examine how First Nations people and communities in Canada have experienced and been affected by recent wildfire evacuations. The partnership includes researchers; First Nations in Alberta, Saskatchewan, and Ontario; and government agencies involved in carrying out or providing support during evacuations, and other relevant organizations. Research was carried out with seven First Nations in three Canadian provinces : Dene Tha' First Nation and Whitefish Lake First Nation #459 in Alberta; Stanley Mission (Lac La Ronge Indian Band) and Onion Lake First Nation in Saskatchewan; and Deer Lake First Nation, Sandy Lake First Nation, and Mishkeegogamang First Nation in Ontario. In this presentation, we will share findings from across research with the seven First Nations that were evacuated due to wildfires. We will examine how differences between the evacuations in the three

provinces affected people's experiences and impacts of the evacuations; and discuss factors that positively and negatively affected evacuation experiences and impacts. Finally, we will make recommendations about how to reduce negative impacts of evacuations on First Nations people and communities.

Keywords: Indigenous peoples, wildfire evacuation, experiences

Bio: Dr. Tara McGee is a professor at the University of Alberta whose research focuses on the human dimensions of wildfire. After completing her undergraduate degree in Ontario, Canada, Tara moved to Australia to complete her PhD research at the Australian National University. While working in Melbourne, she completed a study about social science aspects of wildfire. After returning to Canada, she has extended her human dimensions of wildfire research program in Canada and is also engaged in several international projects.

104. Global Perspectives on Wildfire Community Risk Reduction
Presenter: Lucian Deaton, Project Manager, International Outreach, National Fire Protection Association (NFPA) Wildfire Division
Additional Author(s): Steinberg, Michele, Wildfire Division Manager, NFPA

In June, 2017, the National Fire Protection Association's Wildfire Division and Research Foundation gathered together stakeholders from around the world to collaboratively address wildfire risk reduction and community engagement needs based on their ongoing local outreach. The risk posed by wildfire is a concern internationally, and there are both similarities and differences with how the safety infrastructure in a particular region addresses those risks.

Partners from Canada, Chile, The United Kingdom, Spain, Lebanon, South Africa, and Australia brought their perspectives and experiences to the discussion.

The participants shared their local implementation success stories on engaging with communities and addressing wildfire risk, as well as the challenges they face given their local safety infrastructure.

This presentation will share the six key items identified by the group that make wildfire risk reduction important. The participants discussed factors that affect communicating wildfire risk reduction including defining the audience, messaging strategies, and content. Finally, they identified perceived challenges in establishing and implementing community wildfire risk reduction practices around the world.

This presentation will also share the identified social barriers that arise in connecting with residents and homeowners at a local level about wildfire risk reduction and the work required on improving outreach connections with local officials/decision makers for sustainability of effort.

Keywords: community risk reduction; community engagement; social behavioral change; wildfire; wildland urban interface; international lessons learned; research planning workshop proceedings

Bio: Lucian Deaton manages international outreach for NFPA's Wildfire Division with its current Firewise USA™ National Recognition Program and wildfire educational outreach with partners in South Africa, Canada, Latin America, The United Kingdom, Spain, Lebanon, and Australia. Lucian previously managed the Firewise Program and its collaborative work with forestry agencies in 40

U.S. states. Prior to NFPA, Lucian managed the IAFC's Ready, Set, Go! Program and was a lobbyist on law enforcement and fire service public safety issues before the U.S. Congress and the Federal agencies. Lucian holds Masters degrees in Urban and Regional Planning and Natural Resources from Virginia Tech.

105. Enhancing the Co-Management of Wildfire Risk: Lessons from the Colorado Wildfire Risk Reduction Grant Program

Presenter: Tony Cheng, Director and Professor, Colorado Forest Restoration Institute - Colorado State University
Additional Author(s): Dale, Lisa, Lecturer, Earth Institute - Columbia University
Wolk, Brett, Assistant Director, Colorado Forest Restoration Institute - Colorado State University
Shively, Becca, M.S., School of Forestry & Environmental Studies - Yale University
Morici, Katherine, Research Associate, Colorado Forest Restoration Institute - Colorado State University

In the western USA, where federally-managed wildlands interface and intermix with privately-owned developed lands, there is heightened awareness that managing wildland fire risk is a shared responsibility between public and private property owners. To enhance the capacity of local government and private property owners to work collectively to reduce flammable fuels in and around their communities, the Colorado General Assembly authorized the Wildfire Risk Reduction Grant (WRRG) Program in 2013. In this paper, we assess the progress of the program by examining the extent to which the program has: increased co-management participation by a diverse range of community-based organizations; quantified the extent to which those actions reduced wildfire hazards on non-federal lands; and embodied adaptive governance attributes associated with sustaining co-management of wildfire risk. We present three sets of results from granting cycles 2013-2017: distribution of funding by grant size and organizational type; pre- vs. post-treatment fire hazard metrics derived from field collected monitoring data; and participant-observation of WRRG Advisory Committee decision-making meetings between 2013 and 2017. Our study suggests wide variation and asymmetries in community-based capacity to co-manage wildfire risk. Local government (municipal and county) with existing capacity to compete for, administer, and implement large grants disproportionately received WRRG grants, primarily to reduce fuels on local public parks and open space lands. Fire protection districts and homeowners' associations received a smaller percentage of WRRG funds and smaller average award amounts; further, this participation has declined over the granting cycles. Fire behavior modeling suggests that crown fire hazard decreased across grantees; however, surface fuel and surface fireline intensity either remained unchanged or increased, raising concerns about the range of conditions where projects may have led to unintended outcomes on the ground. The WRRG Program appears to have developed several adaptive governance attributes, including: participation of multiple stakeholders on the advisory committee that makes granting decisions; a culture of learning and flexible decision-making integrated into the constitution of the advisory committee; and robust implementation and effectiveness monitoring with frequent reporting to the advisory committee. We conclude by discussing how this policy learning assessment has implications for federal and state programs seeking to enhance local community-based capacity for co-managing wildfire risk.

Keywords: policy, community wildfire mitigation, co-management, adaptive governance

Bio: Tony Cheng is Director of the Colorado Forest Restoration Institute and Professor in the Department of Forest & Rangeland Stewardship at Colorado State University. His primary research interest is in forest governance, policy and administration, with a focus on multi-stakeholder collaborative approaches to promote resilient social-ecological systems linked to forest landscapes. In his capacity as director of CFRI, Tony oversees programs to develop, compile, and apply locally-relevant scientific information to achieve forest restoration and wildfire hazard reduction goals.

106. Promoting Resilient Landscapes through the use of Prescribed Fire in South Florida

Presenter: Justin Shedd, Research Associate, North Carolina State University - Center for Geospatial Analytics
Additional Author(s): Dr. Vukomanovic, Jelena, Assistant Professor of Human Dimensions of Natural Resources, North Carolina State University
Mcknight, Jordan, Chief of Fire and Aviation, Big Cypress National Preserve, National Park Service
Sullivan, James, Chief of Fire and Aviation, Everglades and Dry Tortugas National Parks, National Park Service

South Florida's natural landscapes evolved with frequent, low-intensity surface fires. With fire return intervals between three to five years, fire management at National Park Service Units Big Cypress National Preserve (BICY) and Everglades National Park (EVER) are unparalleled in occurrence and acreage. If the landscape is not managed through prescribed burning, wildfires will occur during the dry season, causing ecological damage and impact millions of people in the surrounding communities due to higher intensity and more severe wildfires. Updated environmental compliance and management plans at BICY and EVER give fire managers the ability to manage wildfires and allow for the implementation of more landscape-scale prescribed fires, that reduce fuel loading, create mosaic landscapes, and are more cost efficient when compared to smaller prescribed fires and the suppression of a wildfire.

We report wildfire suppression costs between 2015 and 2017, changes in suppression response, and the placement of prescribed fires and compare them with costs and management action from previous years. In 2015, the Mud Lake Complex (total of 19 fires for 35,000 acres at 10 million dollars) at BICY changed how Preserve managers responded to wildfires. Instead of compartmentalizing the fires and containing them individually, they were allowed to burn, especially in remote areas. In 2017, the Parliament wildfire (28,000 acres at 3 million dollars) occurred in an area with lower fuel loads thanks to a recent prescribed fire (Windmill). On the other hand, the 2017 Cowbell wildfire (22,000 acres at 20 million dollars) occurred in an area of the Preserve not recently treated through prescribed fire. The elevated fuel loads resulted in a more costly and intense wildfire. In EVER, recent prescribed fires Block B and Hole-in-the-Donut, flanked the Long Pine Key wildfire (3,800 acres at 1.5 million dollars) and effectively stopped the wildfire's spread to the west and south. Fire containment required fewer resources, was more effective, and at a significantly less cost than would had been required had the fuel loading not been reduced with the previous prescribed fire treatments.

Prescribed fire is vital to make the landscapes of South Florida resilient, thereby safeguarding the surrounding communities and the species that call it home. Prescribed fire remains the most cost effective way to mitigate the costs of future wildfires. These cost comparisons highlight the need for continued prescribed and managed fire in South Florida landscapes.

Keywords: resilient, prescribed fire, South Florida, cost-comparison, management

Bio: Justin Shedd is a Research Associate/Fire GIS Specialist at North Carolina State University's Center for Geospatial Analytics. Since 2005 he has leveraged his proximity to the vast spectrum of geospatial students, scientists, and researchers to promote all aspects of geospatial analysis, modeling and technologies to Fire Managers in the Eastern Regions of the National Park Service.

107. Creating a Smoke Resilient Community in a Wildfire-Prone Land.

Presenter: Sarah Coefield, Air Quality Specialist, Missoula City-County Health Department`
Additional Author(s):

In summer 2017, wildfires surrounding Missoula County, Montana ushered in the worst wildfire smoke season in the county's history. With fires burning in every direction, no part of the county escaped the smoke. Seeley Lake, Montana was the hardest hit. Only July 31, 2017, the massive Rice Ridge Fire started filling the Seeley Lake valley with thick smoke on a nightly basis. During the ensuing 50-day wildfire smoke season, the mean 24-hour average PM2.5 concentration in Seeley Lake was 216 μg/m3, with 1-hour PM2.5 concentrations frequently exceeding 1,000 μg/m3. There was a visible haze in the health clinic and elementary school, and stock health advisory messages to stay inside were inadequate in the face of dangerous indoor air quality. When it became clear there were no emergency funds available at the state or federal level to provide clean air solutions, and the smoke would last into the start of the school year, the Missoula City-County Health Department (MCCHD) and local nonprofits, including Climate Smart Missoula, United Way of Missoula County, the Seeley Lake Community Foundation and Bear Trust International provided funds to purchase room air purifiers with HEPA filtration to clean the air in the hardest hit classrooms throughout Missoula County. Climate Smart Missoula also provided HEPA room air purifiers for elderly Missoula residents and Seeley Lake clinic patients. Communities and nonprofits outside Missoula County saw Missoula's efforts and mimicked them, bringing HEPA air purifiers to classrooms around western Montana. MCCHD coordinated the room air purifier distribution effort in Missoula County, but the project would not have been possible without a pilot project Climate Smart Missoula and MCCHD launched earlier in the summer to provide HEPA air purifiers to elderly Missoula residents. The success of Missoula's air purifier distribution effort depended on the groundwork laid before the wildfires hit, established partnerships between government and nonprofit entities, and a ready supply of air purifiers. Wildfire smoke will return, and MCCHD and Climate Smart Missoula are continuing to work together to turn Missoula County into a smoke-resilient community. The county now has a HEPA air purifier cache for deployment during wildfire smoke events and MCCHD is encouraging the incorporation of central HEPA filtration in new school construction and existing public buildings. The Missoula model can be applied to other wildfire smoke-prone communities to build resiliency and protect public health.

Keywords: smoke, resiliency, wildfire, HEPA, air purifier, PM2.5, health

Bio: Sarah Coefield has been an air quality specialist with the Missoula City-County Health Department since 2010. She is lead for smoke management and large projects in the air program and runs point during wildfire smoke episodes.

108. Ten Years of FireWise Communities in Indigenous Communities, South Africa
Presenter: Valerie Charlton, Managing Director, LandWorks non profit company
Additional Author(s):

For many indigenous peoples across the world, fire is their best friend and their worst enemy. South Africa is no different. Poor rural people use fire daily for cooking and warmth, land clearing and promoting green flush for livestock. Landscapes are remote, with little or no emergency response available when there is a wildfire. Evacuation is not an option. Death and injury statistics are high, insurance does not exist and poor people can lose all of their possessions, spiraling into deeper poverty. Working with the U.S.Forestry Service and NFPA, LandWorks introduced FIreWise Community principles into South Africa in 2007. Subsequently, new methodologies have been developed to reach out, educate and attempt to build resilience in rural villages where local peoples depend upon the landscape and the ecosystem services it provides, in order to survive. Respect for cultural practice is inherent in the approach. Lessons learned have been used to reach out to other countries in sub-Saharan Africa, Chile and Indonesia, gradually building a replicable landscape - based approach that still taps into basic FireWise principles .
Over the period, three workshops have been held, bringing community members from across South Africa together to share their FireWise experiences, perceptions and knowledge gained. This presentation will draw on these, as well as our experiences in other countries, to share insights about social dynamics that are helpful when interacting with indigenous communities.

Keywords: Indigenous people, FireWise, rural landscapes

Bio: Val has a business and conservation background. She became involved in the wildland fire community of practice following the January 2000 fires in Cape Town when she was appointed as the co-ordinator of the Ukuvuka Campaign, a 4 year project to increase community resilience on the Cape Peninsula. She went on to be one of the founding members of the South African Department of Environmental Affairs Working on Fire Programme, with the responsibility of addressing fire awareness and education. Subsequently she has been a strong advocate of building community resilience by integrating community based fire management into any wildland fire solution. Val is a member of the International Liaison Committee for the International Wildland Fire Conference series, with the upcoming conference in Brazil, 2019.

109. Influence of wildfire severity and post-fire timber salvage on forest regeneration in mixed-conifer forests
Presenter: Nicholas Povak, ORISE Post-doctoral Fellow, USFS PNW Research Station, Wenatchee Forestry Sciences Lab
Additional Author(s): Churchill, Derek, Forest Health Scientist, Washington Department of Natural Resources, Olympia, WA 98504
Cansler, C. Alina, USDA Forest Service, RMRS, Fire, Fuel, and Smoke Science Program, Missoula, MT 59808, USA
Kane, Van, Research Assistant Professor, School of Environmental and Forest Sciences, University of Washington
Hessburg, Paul, Research Landscape Ecologist, US Forest Service, PNW Research Station, Wenatchee Forestry Sciences Lab, Wenatchee, WA 98801
Kane, Jonathan, Precision Forestry Cooperative, University of Washington, Seattle, WA 98195
Lutz, Jim, Assistant Professor, S. J. & Jessie E. Quinney College of Natural Resources, Utah State University, 5230 Old Main Hill, Logan, UT 84322-5230

Wildfires are the primary change agent in inland western US forests. Large and severe fires have the greatest potential to shift forests into alternative non-forest states that provide fundamentally different ecosystem services. Area burned in large and severe wildfires each year outpaces restoration and reforestation efforts. Consequently, there is a need to evaluate how modern fires are shaping forest conditions, and to assess how vegetation communities recover from wildfire. In this study, we evaluated post-fire forest structure, with an emphasis on tree regeneration success. We selected field plot locations within fires that burned between 1984 – 2006 within the Okanogan-Wenatchee and Colville National Forests in eastern Washington State. Randomly located field plots (n = 248) were stratified by forest type (cold-dry subalpine, moist-mixed conifer, and dry-mixed conifer), remotely-sensed fire severity (moderate or high), and post-fire management (no management or salvage logged without planting). We tallied all seedlings and saplings <4m height by species and height class. Post-fire salvage logging had the most consistent effect on regeneration, leading to higher densities compared to no post-fire management. No significant difference in regeneration density existed between moderate-severity and high-severity burns plots, but conifers tended to be taller following high severity fires. Regeneration density was lowest in dry forests and highest in moist forest and cold-dry subalpine forests. Tall seedlings and saplings were absent more often in moderate severity plots, in plots without salvage harvesting, and in dry forests. However, few plots experienced complete regeneration failures (i.e., 0 seedlings ha-1). Regeneration of all species combined decreased with increasing time since fire, possibly indicating density-dependent mortality processes. Douglas-fir, western larch, and lodgepole pine were the most abundant tree regeneration across all strata. Lodgepole pine was the most abundant overall, but densities were lowest following moderate severity fires on average. Ponderosa pine exhibited unique regeneration patterns compared to other conifer species and was most abundant in dry and moist forests that were not salvage harvested, and in close proximity (e.g., <150m) to surviving mature ponderosa pines. Hardwoods were much less abundant than conifers and tended to occur in high-severity patches. A strength of our study design is the sampling focus on mid-term (10 – 30 years) post-fire regeneration dynamics. Our results demonstrate widespread and abundant tree regeneration across the forest types, fire severities, and post-fire management scenarios we sampled, with few instances of complete regeneration failure observed. In our study area, adequate tree regeneration has occurred following moderate- to severe-fires to ensure forest recovery both with and without post-fire management.

Keywords: regeneration, salvage harvest, wildfire severity, random forest, lodgepole, Washington State

Bio: Nick began his career in ecological research as an REU at the Harvard Forest and gradually moved west to conduct research across the Midwest, Sierras, and Pacific Northwest. After receiving his PhD from the University of Washington – Seattle, Nick worked as a Post-doc with the Institute of Pacific Islands Forestry (Hilo, HI) developing decision support models to help manage invasive species and hydrologic flows in tropical forests. Currently, he studies biophysical drivers of fire spread and severity, decision support modeling for managing dry-forest ecosystems, and complexity in fire-prone systems.

110. Effects of post-fire salvage logging on early-seral ecosystems in western Oregon

Presenter: Christopher Dunn, Research Associate, Oregon State University
Additional Author(s): Bailey, John, Associate Professor, Oregon State University, Corvallis, OR.

Researchers and managers increasingly recognize early seral habitats as an ecologically important seral state in western forests. Fire suppression and forest management objectives contributed to a decline in the abundance of these forest conditions, although recent fire activity may be reversing these trends. However, managers often propose salvage logging of these environments, which may have undesirable consequences on their structure and function. A knowledge gap exists regarding the persistent impacts of these management actions since most studies focus on sampling within a few years following the disturbance. We attempted to fill this knowledge gap by intensively sampling multiple ecological attributes 10 and 22 years post-fire and salvage logging in Douglas-fir forests of western Oregon. We present results for dead wood structure (snags and coarse wood), long-term tree regeneration abundance and composition, early-seral vegetation communities, and wildland fire fuels. We provide key insights derived by sampling one or two decades after creation of early seral forests or salvage logging, informing forest management decisions focused on maintaining ecosystem resilience now and into the future.

Keywords: earl seral, salvage logging, vegetation response

Bio: Christopher Dunn is currently a post-doc with Dave Calkin's lab at the Rocky Mountain Research Station in Missoula, Montana but operates out of the College of Forestry at Oregon State University. For seven years between his undergraduate and graduate studies, he worked in fire suppression and fuels management, and now integrates these experiences into his scientific research often bridging the gap between fire ecology and management. Today he researchers the safety and effectiveness of large fire management, developing new tools supporting strategic land and fire management strategies that improve the safety and effectiveness of wildfire

111. Forest Management Improves the Water Quality by Altering Detrital Chemical Composition
Presenter: Hamed Majidzadeh, Postdoctoral Scholar, Clemson University
Additional Author(s): Coates, Adam, Assistant Professor, Virginia Tech
Tsai, Kuo-Pei , Postdoctoral Scholar, Clemson University
Chen, Huan, Postdoctoral Scholar , Clemson University
Trettin, Carl, Team Leader, USDA
Chow, Alex, Associate Professor, Clemson University

Many people around the globe depend on drinking water sources originating from forested watersheds. Forest management practices, such as prescribed fire and forest harvesting, may impact the litter and duff of forest soils. Litter and duff, here defined as forest detritus, in forested watersheds is the major terrestrial source of dissolved organic matter (DOM) and disinfection by-product (DBP) precursors in source waters. Thus, any alterations to the forest detritus may consequently affect the organic constituents and treatment regimens of source waters.
We conducted a study at a pair of first-order watersheds in coastal South Carolina to better understand the impacts of long-term forest management on forest detrital chemical composition and potential water quality. By comparing the chemical composition of forest detritus originating from a managed watershed and an unmanaged watershed, we observed differences in the chemical composition of forest detritus. Aliphatic, or lipid-like, chemicals were prevalent in primary compounds identified in the detritus from the unmanaged watershed but were not found in the primary compounds of the detritus from the managed watershed. Phenolic, or lignin-like, compounds were the predominant functional group found in principle compounds of the managed watershed. Detritus from the unmanaged watershed contained higher percentages of a few organic pollutants (aromatic and polycyclic aromatic hydrocarbons). In addition, monthly water samples

were collected fro a year from managed and unmanaged watersheds to evaluate impacts of watershed management on disinfection by-product yield and specific DBP formation. Our preliminary data indicating that prescribed burning can decrease the export of DBP precursors in source waters. Fuel reduction techniques, such as prescribed fire and mastication, and harvesting have been utilized in the managed watershed since 1963. It appears that these practices might be of interest to not only reduce hazardous fuel loads but to also reduce some of the organic pollutants that may affect forested water quality and, subsequently, human health.

Keywords: Prescribed Burning, Water Quality, Forest Managment

Bio: Hamed received his Ph.D. from the School of Forestry, Auburn University in 2016, and since, have been working as a Postdoctoral Scholar at Biogeochemistry and Environmental quality laboratory, Clemson University. The overriding goal of his research is to improve the fundamental understanding of water and soil quality responding to extreme events such as wildfire and hurricanes.

112. Using Prescribed Burn Fire Severity Assessments to Estimate Post-burn Hydrologic Risk in Australian Forests and Woodlands

Presenter: Adam Leavesley, Fire Management Officer, Fire Management Unit Australian Capital Territory Parks and Conservation Service
Additional Author(s): Nyman, Petter, Research Fellow, Forest Hydrology Research Group University of Melbourne
Krusel, Noreen, Director Research and Utilization, Australasian Fire Authorities and Emergency Services Council
Sheridan, Gary, Associate Professor, Forest Hydrology Research Group University of Melbourne
Cooper, Neil, Manager, Fire Management Unit Australian Capital Territory Parks and Conservation Service

Research conducted under the auspices of the Australian Bushfire CRC (BCRC) developed methods for assessing post-fire hydrologic risk to human life, infrastructure, and water quality. The work built on many years of investigation conducted by the Forest Hydrology research group at the University of Melbourne in collaboration with water utilities and land management agencies based in the south-eastern Australian state of Victoria. BCRC end-users identified the project for utilization across Australia and a small cross-sectoral team comprising end-users, researchers and Australasian Fire Authorities and Emergency Services Council (AFAC) research utilization staff was established.
The utilization team developed a three phase research utilization plan. The first phase was an Australia-wide assessment of post-fire hydrologic risk and the development of a set of national guidelines based on general principles. This work was resourced by AFAC and delivered in 2014. Phase two was managed by the Parks and Conservation Service of the Australian Capital Territory (ACT), a small jurisdiction (2358 km2; 910 sq mi) which encompasses the national capital of Australia and its water supply catchment in a fire-prone Alpine national park. The aim of phase two was to advance the generalized risk guidelines developed for AFAC and apply them to ACT catchments. The research component was completed in 2016 with the delivery of a suite of GIS tools that built on the algorithms developed for Victorian agencies for assessment of wildfires. Implementation of the risk algorithms in the ACT involved two new operational processes. 1) The adaptation of the US Forest Service FIREMON fire severity procedure to prescribed burns in ACT eucalypt forests; and 2) the application of the erosion risk processes to prescribed burn planning with the aim of minimizing post-burn hydrologic risk. The methods were then successfully applied during the 2017 prescribed burn season. Additional research - phase three – is aimed at parameterizing the post-fire hydrological

models for specific catchments, with the aim of delivering quantitative information on the probability and magnitude of post-fire erosion.
The project has generated some lessons about the research utilization process. 1) End-users must be clear about what they need and have a sound technical understanding of the research. 2) All parties need to have a common picture of what is to be developed and how it is to be used. 3) Researchers should be prepared to synthesize their work such that the complexity of processes does not impede the development of practical tools.

Keywords: post-burn hydrologic risk fuel fire severity research utilization

Bio: Adam Leavesley is a Fire Management Officer with the ACT Parks and Conservation Service where he is responsible for applied research, research utilization, fire management planning and development planning. During bushfire operations he is a crew leader and a member of the Remote Area Fire Team. He holds a PhD in fire ecology from the Australian National University.

113. Coconino County, AZ - Pre-Fire Assessment of Post-Wildfire Flooding and Debris Flow Risk

Presenter: Joe Loverich, Hydrologist, JE Fuller Hydrology and Geomorphology Inc.
Additional Author(s): Youberg, Ann, PhD, Senior Research Scientist, Arizona Geological Survey
Kellogg, Mike, PG, CFM, GISP, Geologist, JE Fuller Hydrology and Geomorphology, Inc
Fuller, Jon, PE, RG, PH, CFM, D.WRE, Hydrologist, JE Fuller Hydrology and Geomorphology, Inc

The 2010 Schultz Fire on the Coconino National Forest was fueled by a very unhealthy ponderosa pine forest under drought conditions and driven by high winds across the steep eastern slopes of the San Francisco Peaks. Following the fire, the severely burned area experienced severe monsoon rain events, which resulted in numerous debris flows, significant erosion, and substantial flooding of downstream residential areas.
In response, Coconino County, AZ sought and received a Cooperating Technical Partner grant from FEMA to perform a County-wide assessment of post-wildfire flooding and debris-flow hazards to understand the potential impacts to downstream communities, in the aftermath of a reasonable-scenario wildfire in Northern Arizona. The study included a countywide reconnaissance-level evaluation, and detailed evaluation of post-fire flood and debris flow hazards for two pilot study areas. The pilot study results were based on field investigations, two-dimensional FLO2D pre- and post-wildfire flood modeling, debris-flow probability, volume and runout modeling, and GIS terrain and geographic analysis.
Study results show that up to 1/3 of buildings and critical facilities in Coconino County are at some level of increased risk of post-fire flooding, if no actions are taken to reduce the risk of severe wildfires. Within the two pilot study areas, a reasonable-scenario wildfire could increase flood peaks by a factor of 7-8 times the existing 100-year flood estimates, with up to a 350% increase in the number of buildings in flood-prone areas. Private homes, public buildings, roads, major transportation corridors, water supply, and other public utilities could all be adversely impacted by post-fire floods and debris flows.
Study results also indicated that forest health initiatives can effectively mitigate much of the post-fire flood and debris flow risk. Watershed modeling, however, demonstrated that treatments such as forest thinning must involve the entire watershed, including currently designated wilderness areas, to maximize the treatment benefit. Work in wilderness areas will require increased advanced planning, coordination and permitting with federal agencies and, importantly, a change in policy. Other recommended risk mitigation actions include implementation of development guidelines to prevent new development from repeating past mistakes, creation of emergency action plans to

streamline post-fire recovery efforts, and community awareness and public education activities to build support for safe development and mitigation efforts. Conducting this assessment prior to a wildfire allows time to find funding and to implement mitigation measures in a more measured and cost-effective manner.

Keywords: Post-Wildfire Flooding, Debris Flows, Risk Assessment, Forest Health, Planning

Bio: Joe is an engineer with JE Fuller Hydrology and Geomorphology in Flagstaff, AZ. He has 15 years of civil engineering experience in Northern Arizona and has been involved with a wide variety of public and private projects. His main focus is on local to large scale drainage studies and design projects primarily for public agencies. Recent work includes a focus on post-wildfire flooding and debris flow modeling, risk assessment and emergency planning within Coconino County, Arizona.

115. Effects of Prescribed Burning on Whitebark Pine

Presenter: Cara Nelson, Associate Professor, Department of Ecosystem and Conservation Sciences, University of Montana
Additional Author(s): Keville, Megan, Research Associate, Department of Ecosystem and Conservation Sciences, University of Montana

Whitebark pine (Pinus albicaulis Engelm.) is a keystone species of high-elevation ecosystems that provides hydrologic regulation, nutrient-rich food for wildlife, and unrivaled scenery for wilderness enthusiasts. However, this important tree and the goods and services it provides is in decline, due to the combined effects of altered fire regimes, climate change, white pine blister rust (Cronartium ribicola) and mountain pine beetle (Dendroctonus ponderosae). Concern over the status of whitebark pine has led to its listing as a candidate species under the US Endangered Species Act, as well as management activities such as prescribed fire aimed at promoting regeneration, reducing competition from shade-tolerant fir and improving rates of growth. Despite widespread interest in prescribed fire as a tool for whitebark pine restoration, there is almost no information about its ecological effects at the stand or individual tree level. We assessed the effects of prescribed burning on whitebark pine ecosystems by sampling understory plant dynamics, seedling density, tree growth and mortality, and rates of insect and disease infection at two 5-ha sites in the Mission Mountains of Montana using a before-after-control-impact design. Trees in both the control and treated stands had high rates of blister rust infection prior to treatment (ca. 50%). Pre-treatment sampling occurred during summer 2013 and 2014, the burn was implemented in fall 2014, and post-treatment sampling occurred in summer 2015 and 2016. During the two-year period after burning, 40% of mature whitebark pine trees in the treated stand died (31% in year 1 and 7% in year 2). Nearly 20% of the mature whitebark in the treated stand were scorched up into their canopies; all of these trees died. Another 20% of mature trees in the treated stand had bole scorch up to two meters in height; 60% of these trees died. Three trees that did not have any evidence of scorch also died; two of these showed evidence of blister rust infection prior to the burn. In comparison, there was no mortality of whitebark trees in the control stand. We plan to continue to monitor the Mission Mountain sites, as well as to adaptively add additional prescribed fire sites, in order allow for broader spatial and temporal inference about the effects of prescribed fire on whitebark ecosystems.

Keywords: prescribed fire, restoration, whitebark pine, Pinus albicaulis, white pine blister rust ,Cronartium ribicola

Bio: Cara R. Nelson is an Associate Professor in the Department of Ecosystem and Conservation Sciences at University of Montana's Franke College of Forestry and Conservation, Chair of IUCN's Ecological Restoration Thematic Group and past Chair of the Society for Ecological Restoration. Her research focuses on increasing knowledge about ecological processes and their application to restoration of terrestrial ecosystems. Specifically, she and her students study ecosystem responses to abiotic and biotic disturbances, the efficacy and ecological impacts of ecological restoration treatments, and the science behind the selection of native plant materials for repairing degraded ecosystems.

116. Embracing Complexity and Discovering Clarity: Bark Beetles and Fire in Subalpine Forests of the Western US

Presenter: Brian Harvey, Assistant Professor, University of Washington
Additional Author(s): Schoennagel, Tania, Research Scientist, University of Colorado
Parsons, Russell A., Research Ecologist, USDA Forest Service
Wright, Vita, Social Science Analyst and Applications Specialist, USDA Forest Service
Jolly, William M., Research Ecologist, USDA Forest Service
Black, Anne, Social Science Advisor, USDA Forest Service
Corey Gucker, Administrator, Northern Rockies Fire Science Network

Do bark beetle outbreaks make forest fires worse? This question has puzzled policymakers, scientists, resource managers, and residents throughout western North America, where recent beetle outbreaks have killed trees across tens of millions of hectares of forests. As simple as the question seems, clear answers have been elusive, complex, and nuanced. Here, we synthesize insights from forest ecologists, fire ecologists, fire behavior scientists, and forest managers, bringing new insight relevant to the challenges of managing western North America's outbreak-impacted subalpine forests.

We found that the specific question, approach, and scale of interest provided different lenses to view bark beetle and forest fire interactions that provided very different, but often congruent, insights. In particular, the spatial scale of study yielded distinct but nested information about the 1) regional probability of wildfire following BB outbreak, 2) observed fire severity in BB affected forest landscapes, and 3) modeled fire behavior within a stand. Likewise, the temporal scale of study (pre outbreak -> during outbreak -> post outbreak -> during the fire -> immediately post fire -> long-term post fire) also yielded distinct information particular to the timing of the two disturbances. Conflating temporal and spatial scales have contributed to confusion about bark beetle and fire interactions, but distinguishing studies based on these scales of observation lends valuable clarity. For example, questions about immediate firefighter safety in post-outbreak forests are profoundly different than questions about long-term forest resilience to bark beetle outbreaks and fire, and answers to those respective questions will diverge correspondingly. Our synthesis re-frames the state of the knowledge about bark beetle – fire interactions, and brings a new message of clarity. While there is legitimate concern that bark beetle outbreaks may alter wildfire behavior, potentially increasing risks to firefighters or with other undesirable effects, multiple lines of research confirm there is a low probability that post-outbreak subalpine forests will burn, and severe consequences are only manifest in some locations and for some variables. As both disturbances are expected to continue in the future, we also highlight key unknowns and questions that need answering in order to sustainably manage forests in the face of beetle outbreaks and fire.

Keywords: bark beetles, forest fire, fire likelihood, burn severity, subalpine forests, Rocky Mountains

Bio: Brian J. Harvey is an assistant professor in the School of Environmental and Forest Sciences at the University of Washington. His research focuses on understanding the nature of forest disturbances (e.g., fires and insect outbreaks) – and how forest structure and function is shaped by disturbances, interactions among disturbances, and climate. Dr. Harvey's work emphasizes field studies that are integrated with large spatial datasets and analyses, drawing on insights from landscape ecology and community ecology. Over the last 10 years, he has conducted research on the disturbance ecology of forests in coastal California, the Rocky Mountains, and the interior Pacific Northwest.

117. Relating Burn Severity and Short-Term Ecological Effects of Wildfires in High-Elevation Lodgepole Pine (Pinus contorta) and Subalpine Fir (Abies lasiocarpa) Mixed Forests
Presenter: Bryn Marah, Graduate Student, University of Wyoming
Additional Author(s): Scasta, John, Assistant Professor, University of Wyoming

Fire is an ecological and social feature that varies across dominant vegetation types, environmental drivers, and social dynamics. The combination of global climate change, active fire suppression, beetle kill, and reductions of timber harvest have influenced North American fire regimes and mean fire return intervals which have subsequently altered fuel structure and composition from pre-colonial time periods. Combined with predictions for greater acres burned and increased fire behavior, the need to study and understand short-term post-fire recovery and the complex ecological effects from these fires is paramount for the effective management of forest ecosystems and natural resources. Moreover, federal agencies are increasingly aware of the need to strategically allow fire to function while continuing to protect life and property. The Medicine Bow-Routt National Forest in Colorado and Wyoming experienced several fires in the year of 2016 including the Beaver Creek Fire (Colorado and Wyoming) and the Broadway Fire (Wyoming). The Beaver Creek Fire was highly complex due to the overlap of jurisdictional boundaries, surface ownership, fire weather, acres burned, and cost of the incident. We are analyzing ecological responses to wildfire events in the Rocky Mountains with altered lodgepole pine (Pinus contorta) and subalpine fir (Abies lasiocarpa) mixed fuel types that have exhibited unusual fire behavior. We analyzed the Beaver Creek and Broadway fires as one experimental unit (n=18). We evaluated short-term forest recovery relative to different estimates of burn severity with AICc analyses to determine top models for conifer seedling density, total herbaceous cover, and bare mineral soil. We also quantified hydrologic, soil, and vegetation composition post-fire relative to fire and landscape features with multivariate analysis, specifically redundancy analysis (RDA). These results will be important in their application to incident and post-burn management for the future. This study is underway in collaboration with the United States Forest Service, the University of Wyoming, and the Southern Rockies Fire Science Network. Two years of post-fire results and implications of the project will be shared during the discussion.

Keywords: burn severity, ecological effects, short-term recovery, wyoming, colorado, lodgepole pine, subalpine fir, high elevation

Bio: Bryn Marah is a graduate student at the University of Wyoming pursuing a Master of Science degree in Rangeland Ecology and Watershed Management. She also works as a Pathways Intern for the United States Forest Service on the Grand Mesa, Uncompahgre, and Gunnison National Forest in Colorado and the Medicine Bow-Routt National Forest in Colorado and Wyoming in the resource of Rangeland Management. Additionally, Bryn serves as an Assistant Program Manager for the

Oral Presentations

Southern Rockies Fire Science Network attempting to identify knowledge gaps in fire science and to facilitate collaboration between researchers, managers, and communities.

118. Vegetation changes, tree physiology, and bark-beetle mortality in relation to open and enclosed irrigation channels: A case study within a wildland-urban interface forest in western Montana

Presenter: Eric Keeling, Assistant Professor, State University of New York, New Paltz
Additional Author(s):

The wildland-urban interface (WUI) is an area where wild, protected public lands are found adjacent to private lands that may include homes, farms or pasture. In parts of the western US, the WUI is commonly dominated by dry, coniferous forests. In recent decades, these forests have experienced widespread drought and drought-related forest changes such as bark beetle infestations and increasing numbers of fires.
An unexamined factor potentially affecting WUI forests are irrigation channels used to convey water to nearby farms. On the eastern front of the Bitterroot Mountains in Montana, irrigation channels are extensive, with multiple diversions and branching channels running laterally off of every major creek flowing into the Bitterroot Valley. Plant communities growing downslope from open channels may be acclimated to artificially moist soil conditions and enclosing a channel probably deprives vegetation of historical levels of soil moisture. The combination of both open and recently-enclosed channels running across the same landscape may create a complex mosaic of differing and changing soil moisture conditions. This mosaic could have significant effects on forest community structure and composition, which in turn can affect forest resilience to drought, beetle infestation, and fire.
I studied the effects of two irrigation channels (a downslope, open channel and an upslope, recently-enclosed channel) on plant community composition, tree water status and growth, and patterns of bark beetle mortality in a WUI ponderosa pine/Douglas-fir forest experiencing long-term drought. Low-lying swale areas below the recently-enclosed, upper channel had extensive down dead wood and showed shifts from mesic understory plant species to more xeric species. Tree density and basal area declined in swale areas below both channels. Ponderosa pine below the enclosed channel showed evidence of water stress (low water potentials) and negative growth responses to the channel enclosure. In contrast, hillslope trees below the open channel had higher growth rates and water potentials compared to trees above that channel. Beetle-kill was highest between the two channels, the area most-likely affected by upper channel enclosure.
The case study provides evidence that plant community composition, tree physiology, and patterns of tree mortality in forests may be affected by irrigation channels interacting with small-scale topography. Although the findings require corroboration by further testing at broader spatial scales, the possibility that irrigation channels may be causing such changes warrants the attention of WUI forest managers and land owners concerned with forest resilience to fire.

Keywords: Irrigation channel ditch canal; drought; ponderosa pine; wildland-urban interface; bark beetle

Bio: Eric Keeling earned his PhD in Organismal Biology & Ecology from the University of Montana, where he studied the effects of fire and fire-exclusion on ponderosa pine forests in remote wilderness sites in Montana and Idaho. He is currently an assistant professor at SUNY New Paltz in New York, where he studies cliff ecology and fire ecology in the Shawangunk Mountains. He also continues research in Montana at a long-term forest ecological research site in the Bitterroot Valley that includes land homesteaded by his great-grandfather.

119. Managing post-fire landscapes: lessons from natural regeneration and planting guidelines
Presenter: Camille Stevens-Rumann, Assistant Professor, Colorado State University
Additional Author(s): Morgan, Penelope, Professor, University of Idaho
Blades, Jarod, Research Scientist, University of Idaho

As large wildfires continue to burn across large landscapes in the western US, we are increasingly faced with how to manage post-fire environments. Within these burned landscapes, climate change has a large potential to influence natural tree regeneration, and the success of planted seedlings. We used a multi-regional dataset across 52 fires that burned between 1988-2011 to look at both natural tree regeneration and fuel complexes vary through time. Lower tree regeneration and regeneration failures are occurring under the warmer and drier climatic conditions experienced since 2000. The regeneration failures were seen at higher proportions in dry forests where >70% of sites burned in the 21st century have not yet achieved similar pre-fire densities, while >40% did not have any tree regeneration. Meanwhile fuel accumulation peaks 14-20 years post-fire, with loadings exceeding the recommended biomass during this period. With this combined data, we explore a decision support tool for where to successfully plant seedlings especially in a warmer climate with the increased likelihood of reburning. As we manage forested ecosystems into the coming decades we must adapt our management not only for future climate but also the possibility of increased disturbance frequency that may accompany these changing climatic conditions.

Keywords: tree regeneration, tree planting, fuel loading, post-fire recovery

Bio: Camille is an assistant professor at Colorado State University. She studies disturbance ecology, primarily focusing on post-disturbance recovery. Her interests range from individual plant responses to disturbances to ecosystem and landscape scale responses.

120. Climate Variability Impacts Growth and Post-Fire Tree Regeneration Differently among Juveniles and Adults of Ponderosa Pine and Douglas-fir
Presenter: Lacey Hankin, M.S. Student, University of Montana
Additional Author(s): Higuera, Philip, Associate Professor, University of Montana
Davis, Kimberley, Postdoctoral Research Scientist, University of Montana
Dobrowski, Solomon, Associate Professor, University of Montana

Climate change is increasingly altering forest disturbance regimes, including the size and frequency of wildfires, and post-fire forest dynamics. We studied the impacts of wildfire and climate variability on lower treeline forests in the U.S. northern Rocky Mountains by quantifying how post-fire tree establishment and radial growth varied with seasonal climate conditions. We sampled 1457 seedlings across 33 sites that burned in moderate- to high-severity wildfires between 1992 and 2007, and 418 adult trees across 12 sites that burned in low- to moderate-severity wildfires between 1910 and 1987. We reconstructed establishment rates of the dominant lower treeline species, Pinus ponderosa and Pseudotsuga menziesii, using dendrochronology to precisely age seedlings at the root-shoot boundary. We then measured annual radial growth in all samples. To quantify the relationship between recruitment and climate, we compared recruitment events (i.e., years with >20% of total site recruitment) to seasonal climate conditions (e.g., climatic moisture deficit, growing degree days) using superposed epoch analysis. To quantify growth-climate relationships, we performed moving correlations spanning the 20th and early 21st centuries, for each species and for juveniles (i.e., < 25 yr old) and adults (i.e., >25 yr old) trees independently.

We identified 44 recruitment events across the 33 seedling sites, with episodic regeneration largely occurring within five years of a wildfire. Ponderosa pine recruitment was more sensitive to growing season climate than was Douglas-fir. Annual moisture deficit and temperature metrics (i.e., growing degree days, maximum temperature) were significantly lower than average two years prior to and during the year of ponderosa pine recruitment events ($p < 0.05$). The significance of antecedent climate suggests an important role of cone production (in surviving trees) for post-fire regeneration, while cooler conditions coincident with recruitment events likely reflect the importance of moisture availability for germination.

Similarly, ponderosa pine radial growth was more sensitive to growing-season climate than was Douglas-fir. Growth-climate relationships in both juveniles and adults also varied over the past century: both were more strongly correlated with growing-season climate during the early 20th century relative to recent decades. The changing drivers of tree growth suggest that the degree of climate limitation for growth varies through time. Our results indicate that in recent decades, climate has been more strongly related to post-fire recruitment pulses than to radial growth, suggesting that recruitment will be the more limiting factor for the resilience of lower treeline forests to future changes in climate and fire activity.

Keywords: conifer seedlings, tree rings, Pinus ponderosa, Pseudotsuga menziesii, Rocky Mountains

Bio: Lacey is a recent MS student in the Systems Ecology Program at the University of Montana. She studied post-fire regeneration and growth of ponderosa pine and Douglas-fir in the Northern Rockies, using dendrochronology and statistical modeling. Lacey graduated from Williams College in 2014 with a B.A. in Biology and History.

121. Webinars as Tools to Bridge the Fire Science – Management Divide
Presenter: David Godwin, Coordinator, Southern Fire Exchange, University of Florida
Additional Author(s):

Boundary spanning programs are designed to work across professional divides to facilitate information exchange among disparate networks. Nationwide wildland fire boundary spanning programs like the Joint Fire Science Program (JFSP) funded Fire Science Exchange Network have documented numerous examples of successful strategies and events for connecting the fire management and fire science communities. Since 2012, the JFSP Southern Fire Exchange (SFE) has hosted over 50 free webinars with fire scientists, fire managers, ecologists and a wide variety of topic experts. These online events have used modern technology to bridge professional, cultural and geographic space to connect with over 5,000 participants from across the globe. SFE webinars have been a cost-effective medium for sharing timely and relevant information that has often only been available to conference or workshop participants. By blending webinars with various evaluation methods, SFE has been able to collect data that show that these are effective tools for a small program to have regional boundary spanning impacts.

Keywords: fire science, technology, webinar, boundary spanning, Southern Fire Exchange, Fire Science Exchange Network

Bio: David Godwin has been the Program Coordinator for the Joint Fire Science Program funded Southern Fire Exchange since 2013. He works with interagency partners to develop programs, events and opportunities designed to increase the relevance and application of wildland fire science information in land management decisions across eleven states in the Southeastern U.S. The users of those programs include private landowners, agency land managers, NGO land managers, scientists, researchers and students. He has a B.S. in geography from Florida State University and a M.S. and Ph.D. in forest resources and conservation from the University of Florida.

122. Education in fire management and fire management in education
Presenter: Heather Heward, Senior Instructor, University of Idaho
Additional Author(s): Leda Kobziar

Fire management, as a whole, needs the critical thinking, ethics building, and skill development that can be achieved through higher education. Higher education needs the work ethic, understanding of the physical environment, and diverse experience that can be developed through work in fire management. The disciplines of fire education and fire management are often working independently – both furiously working to identify and overcome the many challenges associated with a changing landscape, climate, and culture. Each has a unique potential to contribute to the other if only the interest and opportunity existed. Across the country, fire programs exist that are working to develop informative and engaging fire curriculum, but it can be challenging to know what is most important to teach and to find the right audience for the material. In turn, fire managers are often struggling to find relevant accurate and engaging material to train current and potential employees. It is in the best interest of both fire managers and fire educators to collaborate, which will expedite the progress of all those hoping to foster new ideas and action in the world of fire.

Keywords: Fire Education, collaboration

Bio: Heather Heward is a Senior Instructor at the University of Idaho. She started her career in wildland fire in 2002 and completed eight seasons of wildland fire suppression while finishing her Undergraduate and Masters Degrees at the University of Idaho focusing on wildland fire management. Her notable achievements include providing students with real-world applications to their education and providing them with the experiences they need to move forward with their individual career plans in the area of fire ecology and management.

123. Ground Safety Crew Lessons Learned
Presenter: Rebekah Fox, Associate Professor, Texas State University
Additional Author(s): Snyder, Dale, Assistant Fire Management Officer/ Forest Saw Program Coordinator BC 11 Forest Service National Forests and Grasslands in Texas, Angelina / Sabine National Forests
Viktora, Alex, Assistant Center Director Forest Service Wildland Fire Lessons Learned Center
Bell, Heath, Forest Safety Officer, National Forests in Alabama

In the last few years, the Interagency Wildland Fire Community has experienced a growing demand for mobilizing ground safety crews during ongoing incidents, especially during extended fire seasons to capture and share lessons learned. Although the current library of learning documents (primarily in the form of Rapid Lessons Sharing Documents) was mostly created by people who were working a fire, it is no longer completely feasible to think that those who are actively working a fire will be able to conduct interviews, gather information, perform research, and collectively write reports. As such, the ground safety crews are being used more and more.

Although we are still learning about the best ways these teams function, we have learned quite a bit about what works and what doesn't work when it comes to a) forming these teams, b) framing them for those who will come in contact with them, c) performing while on the teams, d) supporting these teams from the regional office, and e) publishing their work on the Wildfire Lessons Learned Center website.

This presentation will include lessons learned about the teams, particularly focusing on pragmatic considerations for working in the field including interviewing and suggestions for standardizing the field reporting and writing processes.

Keywords: Ground Safety Crew, Roving Safety Teams, Rapid Lessons Sharing

Bio: Dr. Fox's research falls into three categories; 1) organizational rhetoric, with a focus on power, control and learning in organizations, 2) health communication with a focus nursing work, and 3) the rhetoric of social movements, with foci in environmental rhetoric, freedom of expression, and political communication. Dr. Fox has authored or co-authored peer-reviewed journal articles and book chapters, as well as presented over 45 regional, national, and international conference presentations. Dr. Fox is also a member of the faculty cadre for the Learning From Unintended Outcomes Annual Training for the US Forest Service National Advanced Fire Resource Institute (NAFRI).

124. A Centre of Excellence for Prescribed Burning

Presenter: Deb Sparkes, Senior Project Officer, AFAC
Additional Author(s):

Prescribed burning in Australia is delivered to meet a number of objectives including fuel reduction, maintaining ecological processes and achieving silvicultural outcomes. Historically, prescribed burning programs have been regionally focussed depending on agency priorities and processes that have developed in response to the natural environment in which they operate. In 2009, the state of Victoria witnessed catastrophic fires that prompted a Royal Commission report. Land management agencies and rural fire services recognised that the recommendations of the Commission regarding prescribed burning would have national implications and that a holistic and consistent approach to prescribed burning across Australia would increase confidence and capability in delivering prescribed burning programs.
AFAC, the national council for fire and emergency services in Australia and New Zealand and the Forest Fire Management Group, a Commonwealth governmental sub-committee, with established networks and collaboration models were in a position to develop a project that sought to align a number of factors of prescribed burning into nationally agreed principles, guidelines and frameworks.
Between 2011 and 2017 the National Burning Project developed a range of products that encompass the end to end process of prescribed burn planning from setting objectives, strategic, program and operational planning, risk management, training and performance measures.
The material produced draws on extensive consultation across the fire and land management sector, and reflects best practice considerations for prescribed burning that are relevant irrespective of location, size or complexity of the organisation.
As the project drew to a close in June 2017 it was identified that key challenge would be to see the national frameworks and methodologies implemented into practice with enhanced, improved and new information and research used to maintain 'best practice' in prescribed burning.

AFAC Council endorsed establishing a "Centre of Excellence for Prescribed Burning' with the intention that the Centre would draw on the National Burning Project knowledge and implement the products and outcomes of the project through the next five years and beyond. It is intended to also provide coordination and leadership to a network of institutions collaborating to provide program advice, best practice, research, support and training to prescribed burning practitioners to ensure continuation of accumulated knowledge and capability.

This presentation discusses the key principles of the National Burning project outcomes and the objectives and initiatives of the Centre of Excellence that will be used to increase the capability of practitioners to deliver prescribed burning programs.

Keywords: Prescribed Burning National Guidelines Frameworks

Bio: Deb Sparkes is a Senior Project Officer working with AFAC to deliver national projects including the Centre of Excellence for Prescribed Burning and the National Fire Danger Rating System.
Prior to this she worked with rural fire and land management agencies involved in prescribed burning to help deliver outcomes of the National Burning Project for AFAC and the Forest Fire Management Group.
Deb has a Masters of Forest Ecosystem Science and is captivated by the links between fire and landscape health. Her current roles draw on a convergence of her previous experiences in project management, stakeholder engagement, professional writing and service delivery.

125. Opportunities and Disruptions Across the Continuum of Radio Training

Presenter: Elena Gabor, Associate Professor of Organizational Communication, Bradley University
Additional Author(s): Fox, Rebecca, PhD, Associate Professor, Texas State University
Thomas, David, Renoveling, Utah
Black, Anne, PhD, Social Science Advisor, Rocky Mountain Research Station
Ziegler, Jennifer, PhD, Associate Professor, Valparaiso University

In our 2017 IJWF paper, we highlighted the misalignment between the communication skills needed in the field and the training offered to rookies entering the field of firefighting. Drawing from the same data set, we contrast the different training needs expressed by rookies on one hand, whose concerns may be related to the "what" and "how" and those expressed by managers on the other hand, whose concerns center on strategy and the "why". In our interviews, we found that rookies may be more concerned with communication that impacts self-esteem, apprehension, and identity, while managers were concerned with loss of radio skills and "getting rusty" during breaks from the fire season. We provide suggestions for how to incorporate more experiential activities in introductory training courses
to enhance listening, talking and technical radio skills, as well as more opportunities for managers to "shadow" those in other roles to see their communication needs from different perspectives. What may currently function as disruptions in skill maintenance can become opportunities for continuity.

Keywords: radio communication, training, alignment

Bio: Elena Gabor (Ph.D., Purdue University) is an Associate Professor at Bradley University, Peoria, IL, USA. Her research interests focus on issues of occupational socialization, work, communication, identity, and careers. Her work has appeared in peer-reviewed journals such as Qualitative Research in Organizations and Management: An International Journal (Highly Commended Paper Award, 2013), in the Journal of Ethnographic and Qualitative Research, Intercultural Communication Studies, and the International Journal of Wildland Fire. She has worked on a research grant with the Forest Service studying radio communication in wildland fire.

126. Washington's 20 Year Forest Health Strategic Plan: Preparing Landscapes for the Future.
Presenter: Derek Churchill, Forest Health Scientist, Washington Department of Natural Resources
Additional Author(s): Hersey, Hersey, Forest Health Acting Program Manager, WA Dept of Natural Resources
Dozic, Aleksandar, Cartographer, WA Dept of Natural Resources

The State of Washington has initiated a major initiative to address declining forest health conditions and projected increases in wildfire risk across Central and Eastern Washington. The goals of this ambitious effort are to restore and manage forested landscapes at a pace and scale that reduces the risk of uncharacteristic wildfires and increases the health and resilience of forest and aquatic ecosystems in a changing climate for rural communities and the people of Washington. Record setting wildfire years in 2014 and 2015 provided the impetus for the state legislature to unanimously pass legislation and approve funding for the Washington Department of Natural Resources (DNR) to lead this effort. The initiative was formally launched with the release of a 20 Year Forest Health Strategic Plan in 2017. The plan was crafted with the direct involvement of over 30 organizations and builds on many years of collaboration on Federal forests in Washington that has created the social license for large scale restoration.

The 20 Year Plan lays out a science based framework for prioritizing watersheds for coordinated treatments across different ownerships. Every two years, the DNR will select a set of planning areas based on a data driven prioritization and local stakeholder input. The DNR will then conduct landscape evaluations that combine quantitative assessments of departure from historical conditions, fire risk, projected drought stress, habitat for focal wildlife species, aquatic function, insect vulnerability, economics, and operational feasibility. Results will be synthesized into a landscape prescription that will identify treatment targets and potential treatment locations. Landscape evaluations and prescriptions will be coordinated with Forest Service NEPA planning. The DNR will then work closely with local managers and stakeholders to recommend and prioritize specific treatments that will be packaged into an appropriations request to the state legislature. The legislature has pledged millions of dollars for this effort. The first set of planning areas have been selected and landscape evaluations initiated.

The 20 Year Plan embraces the need for increased use of prescribed and managed wildfire fire along with mechanical treatments. The plan seeks to balance ecological restoration on Federal lands with economic objectives on private and State Trust lands. The plan also establishes a monitoring program to track trends in forest and watershed conditions, assess progress towards plan goals, and inform adaptive management over time. The state is interested in partnerships with research institutions to assist with monitoring.

Keywords: landscape restoration, fire risk reduction, prioritization, social license.

Bio: Derek Churchill is both a forester and scientist who focuses on applying ecological knowledge to on-the-ground forest management challenges across the Pacific Northwest. He is currently a lead scientist for the Washington Department of Natural Resources focusing on stand to landscape restoration and management of fire prone forests. Prior to the DNR, he ran a forest consulting company that specialized in ecological forestry on public and private land. He also was recently a research scientist at the School of Environmental and Forest Sciences – University of Washington.

127. Effects of Prescribed Fire on Aspen and Grassland Restoration in an Elk, Wolf, Bison, Aspen, and Grassland System in Waterton Lakes National Park, Alberta

Presenter: Cristina Eisenberg, Chief Scientist, Earthwatch Institute
Additional Author(s):

We studied aspen (Populus tremuloides) and elk (Cervus elaphus) response to a 2008 prescribed fire (1200 ha) in Waterton Lakes National Park, AB (WLNP), in a site that has been identified as one of the most intact fescue (Festuca spp.) prairies in North America. The fire was set in aspen parkland in elk winter range, to restore aspen and fescue. This site contains 1-2 wolf (Canis lupus) packs. Aspen provide a key elk food, and elk are the dominant herbivore by biomass. Research in non-wolf systems found a positive relationship between aspen sprouting, fire severity, and elk browse, with little to no aspen recruitment. We hypothesized that in an elk-wolf-aspen system, elk would avoid areas of highest fire severity, due to the high predation risk created by thick vegetation and coarse woody debris at such sites, and that fire would increase non-native grass species presence. We measured aspen and elk response to prescribed fire annually from 2008-2017, and grass response to prescribed fire from 2015-2017. We tested our hypothesis using an information theoretic approach, generating predictive models to examine the influence on the proportion of aspen browsed of fire severity (snag basal area), site index (site productivity), shrub cover (proportion), aspen sprout density (per ha), and distance to edge of the aspen parkland (m). We used GPS-collar data to confirm elk activity and camera traps to confirm wolf activity. Elk browse declined sharply as distance from the edge of the parkland increased ($p=0.0008$). Fire severity ($p=<0.0001$), aspen sprout density ($p=<0.0001$), and site index appeared in best-fitting models $< 4\ \Delta$ AIC values, with increases in these variables linked to a decrease in elk browse. Elk avoided areas with highest aspen sprout density, productivity, or fire severity. Elk avoidance of sites with greatest food resources may be associated with avoidance of wolf predation. Park natural resources managers implemented full re-burns in 2015, 2016, and 2017, in which they manipulated fire severity within an experimental framework. Subsequent to prescribed fire treatment, we found that the prairie composed of 96% native prairie indicator grass species, and that prescribed fire had no influence on proportion of invasive grass species, but altered native species composition. In 2017 the Kenow fire burned our study site with mostly high severity, creating a new research landscape. The bison reintroduction underway in this ecosystem highlights the need to understand how prescribed fire and wildfire affect wildlife habitat in WLNP.

Keywords: aspen, fescue, elk, wolves, prescribed fire, wildfire, bison

Bio: Earthwatch Institute chief scientist Dr. Cristina Eisenberg oversees a global research program that brings together scientists, citizen scientists, educators, and communities to address global change. For the past 11 years her personal research has been in the northern Rocky Mountains of North America, where she works with the Canadian federal government and the Blackfoot Confederacy to investigate how wolves, bison, and fire create ecological resiliency, and how Traditional Ecological Knowledge can inform awareness of these relationships and natural resources management. She is a book author, a Smithsonian research associate, and graduate faculty at Oregon state University and Michigan Technological University.

128. Post-fire Recovery of Wildlife Populations
Presenter: Karen Hodges, Professor, Conservation Biology, University of British Columbia Okanagan
Additional Author(s):

Among the many effects of climate change, altered disturbance regimes may offer the most direct route for large-scale and long-lasting transformation of landscapes. In western forests, extensive and severe wildfires have reshaped landscapes for decades to come. For wildlife species, persisting in and navigating through these fire-transformed landscapes is critical if populations are to avoid local extirpation, but the recent record-setting fires may challenge local persistence of some species. For many species, ecologists do not know what features of post-burn landscapes enable animals to use the burned area, nor how quickly post-fire habitat conditions become suitable. I have addressed such questions via systematic reviews of studies examining responses of mammals to forest fires, plus field-based research on snowshoe hares, Canada lynx, and marten. This work highlights that ecologists lack a comprehensive understanding of how wildlife species respond to fire. Our recent review of the small mammal – fire literature signals that most such studies address stand-scale patterns in species presence or abundance, rather than examining behaviour, physiology, population dynamics, or landscape-scale effects. In contrast, studies on ungulates and carnivores in burned landscapes tend to focus on single species, measure browse offtake, or examine behaviour of individual animals across multiple habitat types. Our fieldwork on snowshoe hares, Canada lynx, and marten shows that these animals respond strongly to fire size, fire severity, residual structure, and rapidity of shrub and tree regeneration. Fire age is a weak predictor of use by these species, largely because post-fire heterogeneity is not well predicted by time-since-fire, but the animals respond directly to the available vegetation or downed woody debris. Collectively, our reviews and our field data suggest that maintaining populations of mammals in burned landscapes will hinge on spatial configuration of burned and unburned stands and the post-burn heterogeneity. Current fire management that encourages complete burn-out or post-fire salvage logging will reduce post-fire heterogeneity, and consequently may challenge recovery of mammal populations. Our data suggest wildlife species may be resilient to post-burn landscapes provided substantial post-fire heterogeneity is retained.

Keywords: wildlife, habitat, small mammals, large mammals, lynx, snowshoe hare, marten, conservation

Bio: Dr. Hodges is a professor and Canada Research Chair in conservation biology. Her research focuses on forest wildlife, habitat loss, endangered species policy, and predator-prey interactions. She also is interested in how position within the geographic range affects the behaviours and population dynamics of species. She and her students are currently working on post-fire responses of marten, lynx, other predators, small mammals, snowshoe hares, and owls, with work in northern Washington and in southcentral British Columbia.

129. Relationships Among Fire, Fuels, and Prehistoric Ceramic Materials in the Jemez Mountains
Presenter: Connie Constan, Archaeologist, US Forest Service
Additional Author(s): Loehman, Rachel, Research Landscape Ecologist, U.S. Geological Survey
Dyer, Jennifer, Heritage Program Manager, U.S. Forest Service

We present the results and management considerations from two studies of wildfire effects to prehistoric ceramics in the Jemez Mountains of northern New Mexico. Interactions of climate change and past management activities (e.g., fire suppression and subsequent fuels buildup) are linked to more frequent and more severe fires across the western United States. Uncharacteristically severe wildfires cause damage to and loss of information from archaeological sites and traditional cultural properties. It is inevitable that fires will burn through archaeological sites and the shift toward fire patterns that are outside of the historical norm means that cultural resources will be exposed to conditions that are more extreme, and potentially more damaging, than have occurred in the past. We studied fire effects to prehistoric ceramics during a prescribed burn in 2012 and a managed fire in 2014. These data suggest the amount and duration of heating that ceramics can withstand before undesired effects result. We have identified possible thresholds associated with temperature metrics and fuels. The thresholds can be translated to fire environments and fuel loading, which will inform management of archaeological sites. From these two wildland fires, we have formulated some management considerations that are applicable to both fire managers and archaeologists. For example, surface fuels are the primary concern and we need to treat sites (remove heavy fuels) before we re-introduce fire. Serious effects to archaeological materials are less frequent when sites are treated before a fire and fire conditions are moderate to low intensity.

Keywords: Archaeology, Fuels, Fire Environments, Ceramics

Bio: Connie Constan is the Assistant Zone Archaeologist for the Cuba and Jemez Ranger Districts of the Santa Fe National Forest in northern New Mexico. She has been an archaeologist with the U.S. Forest Service for over 15 years, and received her Ph.D. in Anthropology from the University of New Mexico in 2011. Additionally, she is adjunct faculty in the Anthropology Department at the University of New Mexico. Her co-authors Dr. Rachel Loehman and Dr. Jennifer Dyer are with the United States Geological Survey and the U.S. Forest Service respectively.

130. Biotic and Abiotic Drivers of Fire Severity in the Klamath Mountains.

Presenter: Stacy Drury, Research Fire Ecologist, PSW Research Station Davis, USDA Forest Service
Additional Author(s): Alan Taylor, Professor, Pennsylvania State University
Eric Knapp, Research Ecologist, PSW Research Station Redding
Robert Carlson, Forestry Technician, PSW Research Station Redding
Celeste Abbott, Biologist, PSW Research Station Redding
Therese Alves, Biologist, PSW Research Station Redding

The Klamath Mountains provide a unique opportunity for testing the hypothesis that managing or monitoring wildfires is a viable strategy for returning wildfire to historically fire adapted ecosystems. During the past 3 decades, large, often severe wildfires have occurred throughout the region effectively breaking up fuel continuity. In 2015 a 30,000 hectare (75,000 acre) wildfire occurred on the Shasta Trinity and Six Rivers National Forests. The River Complex burned through a mosaic of long unburned forest stands and stands previously burned in historic fires (1999 Onion Fire, 1999 Megram Fire, 2006 Buckhorn fire, 2008 Bake Oven Fire). In 2017, we used a systemic random system to install 105 modified Composite Burn Interval (CBI) plots. CBI plots were installed across a range of fire severity from high to low. At each plot, we identified the fire severity of the most recent fire, the vegetation present before and after the fire, and the amount of downed and dead fuel before and after the fire. Reburned stands were defined as stands that had burned during the historic fires within the last three decades and then were reburned by the River Complex. If CBI plots fell into reburned areas we attempted to determine the fire severity after the historic fire, the vegetation present before and after the historic fire, the downed and dead fuel vegetation before and after the historic fire, and if the fire severity of the historic fire was a potential driver of the subsequent fire.

Initial analysis suggests that many long unburned forest stands within the Klamath Mountains are dense white fir (Abies concolor) stands with abundant ladder fuels. White fir density has likely increased during the 20th century due to the suppression of the historic low to moderate severity fires. Fire behavior and fire severity tend to be high when these white fir stands initially experience fire after the > 100 year fire free intervals. High severity fires tend to promote shrub regeneration which burn severely during subsequent reburns. Preliminary analysis suggest that fire intensity and fire severity of the initial entry burn tends to drive fire severity of subsequent reburns particularly at the extremes. If the initial entry fire is a high severity fire, subsequent fires in the area will likely be categorized as high severity and if the area burns initially as a low severity fire, subsequent fires will also likely be low severity.

Keywords: fire severity, fire management, vegetation change, Klamath Mountains

Bio: Stacy Drury is a research fire ecologist with the USDA Forest Service's Pacific Southwest Research Station. Dr Drury works on all aspects of fire management including fire occurrence, fire behavior, fire severity, and both short-term and long-term fire effects in California. His research program is currently focused on vegetation change due to wildfire and how historic wildfires influence wildfire potentials of subsequent fires.

131. High severity fire: evaluating its key drivers and mapping its probability across western US forests

Presenter: Sean Parks, Research Ecologist, Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, US Forest Service
Additional Author(s): Holsinger, Lisa, Ecologist, Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, US Forest Service
Panunto, Matthew, Ecologist, Missoula Fire Sciences Lab, Rocky Mountain Research Station, US Forest Service
Jolly, W. Matt, Research Ecologist, Missoula Fire Sciences Lab, Rocky Mountain Research Station, US Forest Service
Dobrowski, Solomon, Associate Professor, W.A. Franke College of Forestry & Conservation, University of Montana
Dillon, Greg, Biological Scientist, Missoula Fire Sciences Lab, Rocky Mountain Research Station, US Forest Service

Wildland fire is a critical process in forests of the western United States (US). Variation in fire behavior, which is heavily influenced by fuel loading, terrain, weather, and vegetation type, leads to heterogeneity in fire severity across landscapes. The relative importance of these factors in driving fire severity, however, is poorly understood. Here, we explore the drivers of high severity fire for forested ecoregions in the western US over the period 2002-2014. Fire severity was quantified using a satellite-inferred index of severity, the relativized burn ratio (RBR). For each ecoregion, we used boosted regression trees (BRT) to model high severity fire as a function of live fuel, topography, climate, and fire weather. We found that live fuel, on average, was the most important factor driving high severity fire among ecoregions (average relative importance = 53.1%) and was the most important factor in 14 of 19 ecoregions. Fire weather was the second most important factor among ecoregions (average relative importance = 22.9%) and was the most important factor in five ecoregions. Climate (13.7%) and topography (10.3%) were less influential. We also predicted the probability of high severity fire, were a fire to occur, using recent (2016) satellite imagery to characterize live fuel for a subset of ecoregions in which the model skill was deemed acceptable.

These 'wall-to-wall' gridded ecoregional maps provide relevant and up-to-date information for scientists and managers who are tasked with managing fuel and wildland fire. Lastly, we provide an example of the predicted likelihood of high severity fire under moderate and extreme fire weather before and after fuel reduction treatments, thereby demonstrating how our framework and model predictions can potentially serve as a performance metric for land management agencies tasked with reducing hazardous fuel across large landscapes.

Keywords: Fire severity; fuel; topography; climate; weather

Bio: Sean is a Research Ecologist with the Aldo Leopold Wilderness Research Institute, Rocky Mountain research Station in Missoula, MT. He is interested in spatial interactions between past wildland fire and subsequent fire events. He is specifically interested in how past fires regulate subsequent fires in terms of fire size, severity, ignition potential, etc. Sean is also keenly interested in better understanding how climate shapes fire regimes, which is particularly relevant given that climate change will inevitably result in changes to fire regimes.

132. Ecology as Technology- Investigations into myco-restoration techniques for forestry
Presenter: Jeff Ravage, North Fork Watershed Coordinator, Coalition for the Upper South Platte
Additional Author(s):

Forest managers are constantly under pressure to remove wood from forests because of the danger it poses as a fuel source for fires. However, the current practices of controlled burning, basic wood chipping, or wholesale removal of the wood from the forest have their own problems. Our speaker, Jeff Ravage will talk about his investigation into the use myco-remediation in forest mitigation practices, which is currently entering its fourth year. The goal of this project is to revolutionize the way forest managers deal with woody debris, and provide an opportunity for forest soils to recover by retaining the nutrients naturally locked away in wood.

Keywords:

Bio: Jeff Ravage is the North Fork Watershed Coordinator for the Coalition for the Upper South Platte and an Adjunct Researcher for Denver Botanic Gardens. Mr. Ravage practices forestry and oversees large forest restoration projects west of Denver. As well as investigating myco-restoration techniques, he is currently helping develop carbon offset protocols for forestry practices and products.

133. Nonlocal Influences: Influence of Domain Size on Wildfire Simulation
Presenter: Marlin Holmes, Graduate Intern, Los Alamos National Laboratory
Additional Author(s): Banerjee, Tirtha, Post Doctoral Researcher, Los Alamos National Laboratory
Linn, Rod, Research Scientist, Los Alamos National Laboratory

From the years 1990 to 2015 the area of land consumed by wildfires in the US has nearly doubled from 4.6 million acres to over 10.1 million acres as reported by the National Interagency Fire Center. This increase in burnt area when compared to a relatively constant number of wildfires over the same period reflects a marked increase in wildfire severity. As such, land managers and other members of the fire science community could benefit from improved understanding of fire physics in this time of elevated wildfire activity. Mechanistic models such as FIRETEC – an

R&D100 winning physics based wildfire code - present new tools to help bridge the gap between reality, experiment, and theory when attempting to understand fire behavior. With this type of model initial fuel loading is specified as well as ambient wind conditions throughout the fire time period. Ambient winds are typically communicated through specifications of boundary conditions at the edges of the domains. Fire behavior depends on the interaction between the fire and the ambient winds which occurs over some distance from the fire. It is desirable to establish the specified ambient winds sufficiently far from the fire to allow a realistic transition from fire-influenced winds to the ambient winds. Unfortunately, increased separation distance from fire to boundaries means a larger computational domain and as simulation increases in domain size, the computational cost increases. In this work, we attempt to answer this question: what is the simulation area where seeking to minimize computational cost by reducing domain size influence wildfire behavior and hence the validity/confidence of simulation? Conversely, is there a point where the simulation domain has become overly large and hence unnecessary/wasteful? In this study, we plan to present results correlating changes in domain size to changes in fire behavior for a series of fire intensities. Potential outcomes of optimal domain size corresponding to fire intensity will help streamline future simulation activities.

Keywords: FIRETEC, wild-land fire behavior, domain size, simulation, boundary conditions

Bio: Marlin Holmes is a Ph.D. student The University of Wyoming and graduate intern at the Los Alamos National Laboratory. At the University of Wyoming, he conducts experiments seeking to understand fundamental physics of turbulent flows, in particular, turbulent swirling wakes. At LANL, he leverages his growing experimental expertise to improve sub-grid turbulence and burning models for their mechanistic wildfire behavior code FIRETEC. When not working to advance the field of turbulence and experimental fluid dynamics Marlin like to engage in STEM outreach in the local community. Marlin Holmes is an NSF fellow, as well as a participant in the African American Partnership Program at Los Alamos National Laboratory.

134. Application of Background Oriented Schlieren on Visualization and Measurements of Convective Mass Flux Around Fire

Presenter: AmirHessam Aminfar, PhD. Candidate, University of California
Additional Author(s): Princevac, Marko, Professor, Department of Mechanical Engineering, University of California Riverside
Weise, David R, Research Forester,USDA Forest Service, Pacific Southwest Research Station, Forest Fire Laboratory

Convective heat transfer plays significant roles in wildland fire spread. To improve existing fire prediction model, it is important to delineate how much energy is transported via a convective mode of heat transfer. Optical density visualization techniques such as Schlieren photography can visualize the convective heat transfer. Background-Oriented Schlieren (BOS) is a novel optical density visualization technique which uses a background with various patterns to visualize the density gradient caused by convective heat transfer in the fluid. BOS technique is used to visualize and characterize turbulent properties of fire propagating through pine needle fuel bed wind and without the presence of wind. A random pattern is used as a background. The convective heat transfer increases the air temperature which results in air density decrease. Since the refractive index of the

fluid is linearly proportional to the density of the fluid, light from the background pattern diffracts from its original path, causing the background image to be seen distorted through the transparent medium. By comparing distorted and undistorted images of the background using various optical flow algorithms, such as simple block-matching and Horn-Schnuck algorithm, displacement vectors are calculated. Since the displacement vectors are linearly proportional to the density gradient in the flow, convective flow of air around the fire can be visualized. After visualizing the displacement vectors, a secondary optical flow algorithm is applied to the images to obtain the velocity structure of the flow. Next, using the velocity structure combined with density gradients of the flow field, convective heat transfer is calculated. Flow visualizations around the flame, together with qualitative and quantitative heat transfer characteristics will be presented for several cases of fuel and wind conditions

Keywords:

Bio: Amirhessam Aminfar, is currently a Ph.D. candidate in Mechanical Engineering at the University of California, Riverside.He received his master of science in Mechanical engineering from the University of California, Riverside and his bachelor's degree in Chemical engineering from the Sharif University of Technology in Iran. His Ph.D. thesis focuses on Application of computer vision in visualization and measurement of various transport phenomena

135. Modeling Containment of Wildfires Managed for Resource Objectives

Presenter: Jesse Young, Research Assistant, Northern Arizona University
Additional Author(s): Huang, Ching-Hsun, Associate Professor, Northern Arizona University
Thode, Andrea, Professor, Northern Arizona University
Ager, Alan, Research Forester, Rocky Mountain Research Station

Wildfire management presents a multidimensional decision space where agency administrators and incident commanders are encouraged to use a wide range of strategies and tactics to achieve management objectives. A historic focus on using full suppression strategies to achieve these objectives has led to a rich understanding of situational circumstances that contribute to wildfire containment under a full suppression strategy. This knowledge has been incorporated into wildfire simulators to limit the extent of wildfire spread when exploring land management and resource objectives. However, the circumstances leading to the containment of resource benefit wildfires that are managed under the strategies of confine and contain, monitor, and point protection have not been empirically explored. This limits both the justification for resource benefit wildfires, and the guidance for their spatial extend in wildfire simulations when exploring the effects of their increased use. To better inform the future application and research of resource benefit wildfires, we have developed wildfire containment model for the southwestern United States by combining data from Incident Management Situation Reports (SIT-209) and Remote Automated Weather Stations (RAWS). Results suggest that the containment of resource benefit wildfires is impacted by wildfire risk, in addition to limiting weather and burning conditions.

Keywords: Resource objectives, wildfire management regimes, wildfire containment

Bio: Jesse Young obtained his undergraduate degree in Economics with a minor in Climate Change Studies from the University of Montana. After completing an internship with the U.S. Forest Service, Rocky Mountain Research Station (RMRS) working on carbon accounting of harvested wood products, Jesse continued to work with RMRS as a Research Assistant while returning to the

University of Montana to obtain his Masters of Economics. His thesis focus was "Economic and Policy Factors Driving Adoption of Institutional Woody Biomass Heating Systems in the U.S." After a short time as a Research Associate with RMRS Jesse began his doctoral program at Northern Arizona University to study the economics of wildfires that are managed for multiple resource objectives (managed wildfires).

136. Numerical Investigation of Aggregated Fuel Spatial Pattern Impacts on Fire Behavior

Presenter: Russell Parsons, Research Ecologist, USFS RMRS Fire Sciences Lab
Additional Author(s): Linn, Rodman, Senior Scientist, Los Alamos National Lab
Pimont, Francois, Research Engineer, National Institute of Agricultural Research (INRA- France)
Hoffman, Chad, Associate Professor, Dept. Forest and Rangeland Stewardship, Colorado State University
Sauer, Jeremy, Software Engineer, National Center for Atmospheric Research
Winterkamp, Judith, Staff Computer Scientist, Los Alamos National Lab
Sieg, Carolyn, Research Ecologist, RMRS Forestry Sciences Lab, Flagstaff, AZ

Landscape heterogeneity plays a key role in species distributions, ecosystem processes and disturbance interactions. Historically, in dry forest ecosystems, low canopy cover and heterogeneous fuel patterns often moderated disturbances like fire. Over the last century, however, increases in canopy cover and more homogeneous patterns have contributed to altered fire regimes with higher fire severity. Fire management strategies emphasize increasing within-stand heterogeneity with aggregated fuel patterns to alter potential fire behavior. Yet, little is known about how such patterns may affect fire behavior, or how sensitive fire behavior changes from fuel patterns are to winds and canopy cover. Here, we used a physics-based fire behavior model, FIRETEC, to explore the impacts of spatially aggregated fuel patterns on the mean and variability of stand-level fire behavior, and to test sensitivity of these effects to wind and canopy cover. Qualitative and quantitative approaches suggest that spatial fuel patterns can significantly affect fire behavior. Based on our results we propose three hypotheses: (1) aggregated spatial fuel patterns primarily affect fire behavior by increasing variability; (2) this variability should increase with spatial scale of aggregation; and (3) fire behavior sensitivity to spatial pattern effects should be more pronounced under moderate wind and fuel conditions.

Keywords: fuel, spatial heterogeneity, canopy cover, fire behavior, variability, FIRETEC

Bio: Russ Parsons is a Research Ecologist with the U.S. Forest Service's Fire Sciences Laboratory in Missoula, MT. Russ received degrees in Forestry from U.C. Berkeley in 1992 (B.S), the University of Idaho in 1999 (M.S.), and the University of Montana in 2007 (Ph.D.) His research focuses on simulation modeling at multiple time and space scales, ranging from landscapes and fire regimes to highly detailed 3-D fuel modeling at stand scales. A key theme of his work is to improve our understanding of how fuel changes alter fire behavior and the consequences of these changes for fire ecology and management.

137. Improvements in Australia's Bushfire Rate of Spread Models Over Time

Presenter: Martin Alexander, Proprietor, Wild Rose Fire Behaviour
Additional Author(s): Cruz, Miguel, Research Scientist, CSIRO, Canberra, ACT, Australia
Sullivan, Andrew, Research Scientist, CSIRO, Canberra, ACT, Australia
Goudl, Jim, Research Fellow, CSIRO, Canberra, ACT, Australia
Kilinc, Musa, Country Fire Authority, Melbourne, Victoria, Australia

Disastrous bushfires that cause loss of human life and property, are common in southern Australia as a result of its fire environment. The accurate prediction of fire propagation across the landscape is imperative to informing safe and effective suppression operations and essential to advise public safety measures.
We analysed the predictive accuracy of several models currently used operationally in Australia to predict rate of fire spread in five different fuel types and compared this accuracy with their former, older, model counterparts. Included in these analyses were models developed in Australia for grasslands, temperate and semi-arid shrublands, and dry eucalypt forests, plus a pair of North American models for predicting crown fire spread rates in conifer forests, the most recent of which is used for exotic pine plantations in the country.
We first calculated error statistics by contrasting model predictions with observed rates of spread using independent datasets comprised primarily of field observations of wildfires and to a much lesser extent, prescribed fires. We then compared the error metrics calculated for older and models to access changes in the error statistics.
Model evaluation results show the current models to have improved prediction accuracy over their previous older counterparts. Mean absolute errors were reduced by 68% in the case of grasslands, 56% for temperate shrublands, 52% for dry eucalypt forests, and 70% for crown fires in conifer forests. The most significant improvement observed was the reversion or reduction of under- and over-prediction biases achieved with the newer models. This study has highlighted the value of continuous improvement when it comes to operational wildland fire spread models.
This presentation is based on a recently published journal article: Cruz, M.G.; Alexander, M.E.; Sullivan, A.L.; Gould, J.S.; Kilinc, M. 2018. Assessing model improvements in predicting wildland fire rates of spread. Environmental Modelling & Software 105: 54-63.

Keywords: fire behavior prediction

Bio: Dr. Alexander is the Proprietor of Wild Rose Fire Behaviour located in Leduc County, Alberta. He retired from the Canadian Forest Service as a Senior Fire Behavior Research Officer in November 2010 following a 34.5 year career. For more information visit on the presenter visit https://www.frames.gov/applied_fire_behavior

138. Tar and gas composition from slow pyrolysis of 15 live and dead plant species from the Southeastern United States

Presenter: Elham Amini, PhD Student, Brigham Young University
Additional Author(s): Howarth, Joel, undergraduate research assistant, Brigham Young Univesity
DeYoung, Jonathan, undergraduate research assistant, Brigham Young Univesity
Fletcher, Thomas H., Professor, Brigham Young University

Wildland fire is an important component of Southeastern United States ecosystems, and can have necessary ecological influences in many ecosystems or can dangerously affect life, property and natural resources. Fuel bed ignition and pyrolysis determine fire ignition and propagation rates in wildland fires, but the details of solid fuel reaction under wildland fire conditions remain poorly understood. In order to improve understanding of the fundamental process related to pyrolysis in fuel beds of southeastern United States forests, the slow pyrolysis experiments of 15 live and dead plant species all of which are native to these forests were carried out in a pyrolyzer under nitrogen atmosphere with a low heating rate (~10-30 °C/min), temperature of 500 °C, and sweep gas flowrate of 100 ml/min. The chemical composition of tar and non-condensable gases were studied using gas chromatography-mass spectrometry (GC-MS) and gas chromatograph-thermal conductivity detector (GC-TCD) techniques, respectively. The tar analysis showed that the major compounds were oxygenated aromatic species, which were mainly phenols. The non-condensable gas analysis showed that CO and CO_2 were the dominant compounds for all live and dead plant species on a dry, wt% basis, followed by CH_4 and H_2.

Keywords: Slow pyrolysis, live shrubs, gas and tar composition

Bio: Elham Amini is a 2nd year PhD student in the Chemical Engineering Department at Brigham Young University, working on a SERDP project to characterize the pyrolysis products of live and dead vegetation from the Southeastern United States.

139. Environmental conditions, not the type of ignition, control the interannual variability of wildfire burned area in the west and southeast US

Presenter: Steven Brey, Graduate Research Assistant, Colorado State University
Additional Author(s): Barnes, Elizabeth, Professor, Colorado State University
Pierce, Jeffrey, Professor, Colorado State University
Fischer, Emily, Professor, Colorado State University

This research contrasts the environmental conditions and meteorology drivers of human and lightning-ignited wildfires in the southeast and western US. Our work provides new insights into how wildfire abundance in the two continental US regions with the most wildfire activity may respond to climate change. For this work, we use the Fire Program Analysis Wildfire Occurrence Data (FPA FOD) to determine wildfire abundance. These data provide the size and ignition source for wildfires occurring between 1992 and 2015. The FPA FOD data show that in the US west, 70% of the wildfire area burned is from lightning-ignited wildfires whereas in the southeast only 27% of the area burned results from lightning ignitions. On average, wildfires in the US southeast are smaller than the US west; however, a similar number of wildfires in each region are associated with National Weather Service air quality smoke forecasts. On average, wildfires within ecoregions in the US southeast occur at higher fuel moisture content values than wildfires in the west. For a given ecoregion, human-ignited wildfires expand the wildfire season, both in terms of the time periods when wildfires occur and when the majority of annual burn area is accumulated. In the southeast, there would be very few large wildfires outside of the summer without human-started wildfires. Despite these differences, annual lightning- and human-ignited wildfire burn area are well correlated with each other and have similar relationships with annual mean temperature, relative humidity, and total precipitation in the majority of ecoregions in the west and southeast. These correlations indicate that annual wildfire burn area for both ignition types are primarily driven by environmental conditions and that changes in burn area that result from climate change may be similar for both (assuming stationary relationships between annual burn area and meteorology).

Keywords: wildfires, human, lightning, ignitions, climate change, variability

Bio: I am a PhD student studying Atmospheric Science at Colorado State University. I completed my B.S. in Atmospheric Science at the University of Washington (UW) in 2013 and my M.S in Atmospheric Science at Colorado State University (CSU) in 2016. Between UW and CSU I worked for Mazama Science. I like exploring and visualizing datasets using open-source software, particularly R and Python.

140. Factors driving wildfire activity: What do we know?
Presenter: Jonathan Keeley, Senior Scientist, USGS
Additional Author(s): Alexandra Syphard, Ph.D., Senior research ecologist with the Conservation Biology Institute

The vast number of structures lost in the 2017 California wine country fires, followed by the unprecedented size of the Thomas fire a couple of months later, serve as a stark reminder of how much we have yet to learn about the drivers of catastrophic wildfires, especially given projections for worsening fire conditions due to climate change. Despite increased recognition that the most important factors driving large wildfires vary across space and time, most fire-climate analyses have been conducted across broad spatial extents that mask geographical variation. Conclusions from these studies could thus result in overly broad or inappropriate management and policy decisions. We used nearly 40 years of fire history data across the contiguous U.S. to correlate annual fire activity with seasonal climate variables within separate geographical regions of similar climate. We asked whether and how fire-climate relationships vary geographically, and why climate is more important in some regions than others. Although seasonal climate variation played a significant role in explaining annual fire activity in some regions, the relative importance of different variables and the overall importance of climate varied substantially. Human presence in terms of population density or proximity to roads was the primary reason that climate explained less fire activity in some regions than others. This suggests that humans may not only influence fire regimes, but their presence can actually override, or swamp out, the effect of climate. These results, along with those of other studies, suggest that factors driving wildfire activity are complex and variable, which hampers our ability to make broad conclusions. Additional factors including fire-weather and long-term drought also need to be parsed out along with seasonal climate and human influences. In conclusion, we know that altered precipitation and temperature are a concern for those parts of the U.S. that exhibit a strong fire-climate relationship. But we also know there is still a lot of work to be done to identify the most important drivers of fire activity across space and time.

Keywords: human influence, seasonal climate

Bio: Jon E. Keeley, is Senior ST research scientist with the U.S. Geological Survey, adjunct professor at UCLA, former program director at the National Science Foundation, recipient of a Guggenheim Fellowship and Ecological Society of America Fellow. He has spent sabbaticals in all five mediterranean climate regions of the world. His research includes ecological life history strategies of plants from fire-prone ecosystems, fire-stimulated seed germination, invasive species, taxonomy of Arctostaphylos, and biochemical pathways of photosynthesis in vernal pool plants. He has over 400 publications, which have garnered more than 20,000 citations. He is senior author of a 2012 Cambridge University Press book Fire in Mediterranean Climate Ecosystems: Ecology, Evolution and Management.

141. What Do We Know about the Emerging Role of Rx Fire in Preventing Mass Extinction?
Presenter: Cecil Frost, Landscape Fire Ecologist, Univ. of North Carolina
Additional Author(s):

Fire, like wind and rain, is a natural environmental parameter on which the diversity of life depends. We are now fully engaged in the final Great Triage; sorting, by intention and by default, all remaining lands into three categories: the Restoration Domain, as in National Parks and private refuges, our

Working Landscapes (multifunctional landscapes) and the Transformed Lands, including cities and intensive agriculture. From the perspective of the planet, the most significant consequence of climate change is not the forced departure from business as usual: economic growth and the flow of food, conveniences and entertainment, but rather extinction of half or more of all species—the greatest threat to life since the initial radiation of terrestrial species in the Devonian over 400 million years ago. Restoring fire to domain 1, our public and private natural lands, will be an absolute necessity for maintaining habitats for the rarer half of all species diversity. The looming, yet unaddressed question is: just where are we on the accelerating extinction curve that shadows the ballistic upturn of CO_2 and global warming?

Keywords: Mass Extinction, Climate Change, Fire and Species Diversity

Bio: Cecil Frost is a landscape fire ecologist with a doctorate from Univ of North Carolina who has spent his career on fire-dependent species and ways to create maps reconstructing pre-European fire frequency and vegetation. After 14 years as coordinator of a state E&T species program (North Carolina), he retired to work full time in fire ecology. In 2004 he was a member of the national team for mapping Fire Regime Condition Class, a precursor to LANDFIRE. He has produced fine-scale maps of pre-European fire frequency for over 3 million acres of lands for USFS, USFWS, NPS, military bases and TNC. In 2016 he received the Stoddard award for Lifetime Achievement in Fire Ecology from AFE.

142. Global fire induced tree loss and its biophysical effects on surface climate
Presenter: Liu Zhihua, Post-doctoral Researcher, The University of Montana
Additional Author(s):

Fire is an important driver for global forest cover change, and can significantly affect the climate service provided by forests. However, the role of fire in driving forest dynamics and its climate feedback is not well studied at large spatial-temporal scale. We used satellite observations and found fire-induced tree mortality accounts for 14.8% of global tree loss, mostly concentrated in the northern high latitude due to high fire severity and larger forested land. Overall, the biophysical climate effect from forest fire is 62% of that due to CO_2 emission effect. The biophysical climate effect from forest fire exhibits distinct seasonal and latitudinal patterns across biomes. The biophysical climate effect due to forest fire is most dramatic at northern high latitudes, and has a warming effect in summer mainly due to reduced evaporative cooling, and cooling effect in winter due to increase in surface albedo. Annually, forest fire has a warming effect, mainly due to reduce in evapotranspiration, and contribute to a positive climate-fire surface feedback. Generally, the positive biophysical climate feedback is stronger in colder biomes. Furthermore, the biophysical climate effect from fire is more controlled by fire severity than burned area; thus underscoring the importance of assessing the cause and consequence of fire severity. Our results showed that fire-induced forest cover change has a different climate feedback from human-caused tree loss through different biophysical control. Therefore, separating fire- vs human-caused forest change is necessary to understand the climate feedback of global forest change.

Keywords: fire, climate change, feedback

Bio: Zhihua Liu, Ph.D., Post-doctoral Researcher, College of Forestry & Conservation, University of Montana

143. Causes of Indonesian Peat Fires: Implications for Research and Policy

Presenter: Kevin Ryan, Senior Scientist, FireTree Wildland Fire Sciences, LLC
Additional Author(s): Andrew P. Vayda, Distinguished Professor Emeritus of Anthropology and Ecology at Rutgers University
Tiomathy C. Jessup, Forest and Climate Advisor, Global Green Growth Institute, Jakarta, Indonesia.
Mark A. Cochrane, Professor, Appalachian Laboratory University of Maryland Center for Environmental Science (UMCES)

Fires in the peatlands of Kalimantan and Sumatra in Indonesia are significant sources of greenhouse gasses (GHG). These fires are widely attributed to land clearing activities associated with palm oil and pulp production, mining, and subsistence agriculture. The scale of peat forest degradation has led to intra- and inter-governmental, academic, and NGO efforts to monitor, document and reduce GHG emissions. Laws and policies are emerging as a result of these efforts. However, naming broad economic reasons for fire use in peatland forests is neither adequate for formulating land management policies nor for implementing fire prevention programs. A more detailed understanding of the biophysical conditions and human activities associated with peatland fires is needed.

GHG emissions depend on the amount and type of fuel and how it is burned. Monitoring and documentation of GHG is limited by the failure to adequately distinguish between surface fires that consume predominantly woody and herbaceous fuels via flaming combustion vs. peat fires that consume organic soil and buried wood predominantly via smoldering combustion. Depending upon a suite of environmental conditions, peat consumption can vary by orders of magnitude if and when surface fires transition to peat soil. Once established peat fires can persist for weeks initiating new surface fires whenever relative humidity and wind are favorable. Thus repeating the cycle.

To be successful fire prevention programs must: 1) recognize the diverse human activities and objectives associated with fire use which, in addition to those mentioned above, include: asserting land-rights, improving hunting, fishing and gathering, and debris burning; 2) accept that many of these activities may be deeply rooted in culture and likely to continue for the foreseeable future; and 3) recognize that not all fire causing activities in and around peatlands lead to sustained peat fires. A better understanding is needed of not only the human activities associated with the ignition, but the timing and methods.

In an effort to gain such understanding, field teams determined the point of origin, described the cultural setting, and attempted to identify the specific ignition device and prevailing environmental conditions. Interviews were also conducted in attempts to assess local people's intentions, their understanding of surface vs. peat fire conditions, and their perception of outcomes.

Results are first steps in long-term research. The methods are outlined and critiqued. The presentation is intended to elevate discussion and dialog among biophysical and social scientists working on peatland fire issues.

Keywords: Fire causes, tropical fire, peatland forest degradation

Bio: Kevin is a senior scientist and environmental consultant with broad experience in the role and use of fire in upland and peatland ecosystems. He participates in restoration and climate-related research and advises policy makers and managers on fire-environmental issues.

144. A synthesis and meta-analysis of ponderosa pine fire regimes from five U.S. regions
Presenter: Shawn McKinney, Ecologist, USFS Rocky Mountain Research Station and University of Montana
Additional Author(s): Abrahamson, Ilana, Ecologist, USFS Rocky Mountain Research Station
Fryer, Janet, Ecologist, USFS Rocky Mountain Research Station
Juran, Ashley, Ecologist, USFS Rocky Mountain Research Station and University of Montana
Murphy, Shannon K., Ecologist, USFS Rocky Mountain Research Station and University of Montana
Zouhar, Kristin, Ecologist, USFS Rocky Mountain Research Station

Quantifying the components of an ecosystem's fire regime and how they vary spatially and with environmental factors can enhance our understanding of regulating mechanisms and improve ecologically based fire management decisions. Individual fire history studies provide detailed information on fire regime parameters, but their scope of inference is constrained by site-level heterogeneity and variation in sampling methodologies. Here we perform a meta-analysis to determine how historical fire frequency varied within and among five U.S. regions where ponderosa pine (Pinus ponderosa) is a major forest component. We systematically reviewed the scientific literature, reports, and unpublished documents for fire history information from the East Cascades, Blue Mountains, Northern Rocky Mountains, Black Hills region, and Colorado. We extracted site-level information (n = 182 sites) on fire frequency (mean fire-return interval), elevation, sampling period, and forest type from 52 studies for our analyses.

Mean fire-return interval (MFI) varied similarly within and among the five regions. East Cascade sites experienced both the shortest average MFI (11 years) and the smallest range in MFI values (19 years), while Colorado sites had the longest average MFI (21 years) and the largest range (63 years) of MFIs. Variability in MFI among the five regions (10% SE) was similar to within-region variability. The Northern Rocky Mountains had the greatest variability in MFI among sites (11% SE), but sites within the other regions had similar variability (%SE < 5% different from the Northern Rocky Mountains). An abrupt end to frequent fire in the early 20th century occurred in all regions, with specific dates varying at the site-level, likely as a function of local human activities.

Mean fire-return interval was positively related to site elevation in four of the five regions. However, the strength of the relationship and the elevation where fire frequency and forest composition changed varied among regions. The elevation range of study sites within regions partially explained the strength of this relationship. Black Hills and Colorado sites had the two largest elevation ranges (1420 m, 1168 m) and the two greatest and only significant correlations (0.62, 0.33) between MFI and elevation. Blue Mountain and Northern Rocky Mountain sites had positive but weak relationships, while East Cascade sites had the second smallest range in elevation and a negative correlation between MFI and elevation. While local elevation appears to be a regulating factor on site-level MFI, other fine-scale (slope, aspect), and broad-scale (regional climate) factors likely dampen its strength.

Keywords: fire frequency, elevation, ponderosa pine, variability

Bio: Shawn is an ecologist with the University of Montana's FireCenter and a cooperator with the USFS Rocky Mountain Research Station where he researches, performs meta-analyses, and writes syntheses on fire regimes. Shawn earned his BA and MS in Ecology and Evolution from the University of Colorado, and PhD in Forest Ecology from University of Montana. His research has focused on understanding impacts of human perturbations in forest communities to inform management.

Shawn worked as a Research Wildlife Ecologist for the USGS Maine Cooperative Fish and Wildlife Research Unit, and Ecologist for the NPS Sierra Nevada Inventory and Monitoring Network.

145. Using NASA's Remote Sensing Datasets and Land Information System to Characterize Lightning Initiated Wildfires

Presenter: Kris White, Applications Integration Meteorologist, National Weather Service, Huntsville, AL and NASA SPoRT
Additional Author(s): Schultz, Christopher, NASA Marshall Space Flight Center
Hain, Christopher, Research Scientist, NASA Marshall Space Flight Center
Case, Jonathan, Research Meteorologist, ENSCO Inc.
Wachter, John (Brent), Lead Fire Application Specialist, United States Forest Service, Redding California
Kahn, Douglas, Graduate Research Assistant, the University of Alabama in Huntsville

Recent work demonstrates that land surface and sub-surface properties are the primary drivers of lightning initiated wildfires and the lightning plays a secondary but important role in ignition. This presentation will examine the antecedent conditions leading up to lightning initiated wildfire events over the United States using various NASA remote sensing assets and the NASA Short Term Prediction and Research Transition Center's Land Information System (SPoRT-LIS). Examples of variables of interest may include LIS 0-10 cm soil moisture, the ALEXI Evaporative Stress Index, LIS total column relative soil moisture and MODIS/VIIRS green vegetation fraction (GVF), which represent moisture and vegetation coverage in the areas which fires do and do not initiate. An additional emphasis will be placed on research related to improving dry fuel estimation from a combination of remote sensing and land surface modeling datasets. An initial subset of more than 900 cases is utilized to perform analysis on all selected parameters at the location of fire starts and locations of other lightning events that do not start fires between 2012 and 2015. Additional cases beyond 2015 are assessed to improve the statistical representation of antecedent conditions prior to wildfire events and to incorporate new lightning data from NOAA's new Geostationary Lightning Mappers on the GOES-16 and GOES-17 weather satellites.

Keywords: lightning initiated wildfire, land surface, fuel moisture, vegetation stress

Bio: Mr. White received his B.S. in Meteorology at the University of Oklahoma in 2002. After graduation, Mr. White worked at the Reagan Missile Test Site on the Kwajalein Atoll, serving as lead mission meteorologist for several test missions, including introductory SpaceX launch tests.
Mr. White entered the National Weather Service (NWS) in Duluth, Minnesota in 2006, and was later promoted to journey and then lead meteorologist at the NWS office in Huntsville, Alabama. In 2011, Mr. White was promoted to Applications Integration Meteorologist, serving both as a lead meteorologist and principal liaison between the NWS and the NASA SPoRT program.

146. The Fire Danger Assessment System: Using NASA Satellite Observations to Map Fire Danger in the United States for Allocation of Fire Management Resources

Presenter: E. Natasha Stavros, Applied Science System Engineer, Jet Propulsion Laboratory, California Institute of Technology
Additional Author(s): Farahmand, Alireza, Ph.D., Post-Doctoral Researcher, Jet Propulsion Laboratory, California Institute of Technology
Reager, JT, Ph.D., Scientist, Jet Propulsion Laboratory, California Institute of Technology

Behrangi, Ali, Ph.D., Researcher, Jet Propulsion Laboratory, California Institute of Technology
Randerson, James, PhD., Professor, University of California Irvine

Fires are a key disturbance globally acting as a catalyst for terrestrial ecosystem change and contributing significantly to both carbon emissions and changes in surface albedo, while also having significant socioeconomic impacts such as billions of dollars-worth of infrastructure lost and thousands displaced from their homes. Consequently, predicting potential fire danger has important implications for allocating limited fire management resources at national and regional scales. Traditional methods for predicting fire danger include calculation of a fire danger index (e.g., the US National Fire Danger Rating System), however these have limited forecast ability due to their dependence on meteorological forecasts, which have reduced reliability after ~10 days. Many studies have demonstrated relationships between hydrologic variables and fire occurrence or area burned throughout the season, but none have investigated the potential of using these relationships for operational forecasting. The objective of this study is to use remote sensing observations of hydrologic variables including soil moisture and vapor pressure deficit to generate monthly predictions of fire danger at scales commensurate with regional management decisions within the US (i.e., Geographic Area Coordination Centers - GACC) such as allocation of federal fire management resources across the globe when local resources are strained. We develop GACC-specific regression models for predicting anomalous area burned by month and then adjust the climatological area burned according to hydrologic conditions from at least two months prior (to account for data latency). Results show that these models can successfully detect the inter-annual variability of wildfire burned area for all GACCs within the United States. This demonstrates the importance of soil moisture and vapor pressure deficit to extend operational forecast ability into the months preceding wildfire activity. Current efforts are underway to expand this work and provide global, gridded forecasts.

Keywords: fire danger; forecast; prediction; hydrology; soil moisture; vapor pressure deficit

Bio: Dr. E. Natasha Stavros is a Science Applications System Engineer at Jet Propulsion Laboratory, California Institute of Technology. She specializes in end-to-end data and information system engineering, which includes facilitating collaborations among interdisciplinary researchers and decision makers (managers & policy), mapping inter-organizational information systems, assessing market needs, and architecting and managing projects/tasks to fill gaps between information demand and data supply. She developed these skills as a fire and terrestrial ecosystem ecologist, but applies them in other complex systems, with particular emphasis on NASA flight projects and data systems. She received a B.A. in Mathematics and Computer Science from the University of Colorado, Boulder where her career with NASA began at the Laboratory of Atmosphere and Space Physics (LASP) doing mission operations and data analysis for data product calibration. She received a M.S. in Environmental Sustainability from the University of Edinburgh, Scotland specializing in remote observation integration into a mechanistic model for forest management, and a Ph.D. in Forest and Fire Ecology from the University of Washington specializing in linking climate, fire ecology, and air quality degradation.

147. Local biophysical patterns interacting with fire weather best explain burn severity patterns in the central Sierra Nevada, California

Presenter: Van Kane, Research Associate Professor, University of Washington
Additional Author(s): Povak, Nicholas A., ORISE Post-doc Fellow, USFS Pacific Northwest Research Station
Kane, Jonathan T., Research Scientist, University of Washington
Collins, Brandon, Research Scientist, Center for Fire Research and Outreach, University of California Berkeley

Wildfire is the most important disturbance agent affecting forest structural patterns across much of the western United States. Increases in the rates of annual area burned have far outpaced restoration treatments across the region, and there is a need to develop improved models for spatial predictions of future fire severity and determine potential ecological impacts. We studied the patterns of burn severity (RdNBR) across Yosemite National Park (YNP) and the adjacent Stanislaus National Forest (SNF) for all fires in the MTBS database from 1984 to 2015, including the large 2013 Rim fire. Our predictors included local climate normals, antecedent weather, topography, past fire history, and for the Rim fire, measures of daily fire weather. We used random forest modeling to 1) identify a parsimonious set of predictors correlated with mortality, 2) examine the nature of the relationship between each predictor and burn severity (e.g., linear or unimodal), and 3) evaluate how the relationship between predictors and severity varies by topographic and local climatic setting. We compared differences in severity patterns for first fires and reburns, and between managed (SNF) and wilderness (YNP) landscapes across ~150 fires including the 2013 Rim Fire. We found that climate normals, antecedent weather, and past maximum burn severities (for reburns) were the strongest predictors of burn severity across all fires. Results suggest that strength of individual covariates vary more among individual fires rather than across management types. Analysis of spatial autocorrelation among burn severity and predictors showed considerable coherence in fire severity and its associated predictors over small to mid-scale space and time. In general, the moderate severity fire class, was the most difficult to predict, which suggests a high degree of complexity among covariates driving moderate severity fire patches across the region. Lastly, we found that modeling Rim fire severity across individual fire days rather than whole fire events often resulted in higher explanatory power, and could help identify shifts in main drivers across fire events. For example, daily fire weather was the leading predictor of Rim Fire severity for only two out of five "plume dominated" progression days, while past fire severity was the leading predictor of reburn severity for other days.

Keywords: burn severity modeling, biophysical, climate, topography, prior fire, RdNBR, random forest

Bio: Dr. Kane has published two papers that model the relationships of biophysical patterns to burn severity in the Sierra Nevada, California. This current work builds on that previous work with more comprehensive modeling and is part of a paired study modeling fire severity in eastern Washington state. His other main research focus is using airborne lidar data to study the effects of different burn severities on patterns of forest structure.

148. Modeling Fire Severity in Eastern Washington Using Mapped Surfaces of Climate, Weather, and Topography

Presenter: Kane Jonathan, Research Consultant, University of Washington
Additional Author(s): Povak, Nicholas, ORISE Post-doc Fellow, USFS PNW Research Station, Wenatchee Forestry Sciences Lab, Wenatchee, WA 98801
Kane, Van, Research Assistant Professor, School of Environmental and Forest Sciences, University of Washington, Seattle, WA 98195
Cansler, C. Alina, Research Forester, USDA Forest Service, RMRS, Fire, Fuel, and Smoke Science Program, Missoula, MT 59808
Lutz, James, Assistant Professor, S. J. & Jessie E. Quinney College of Natural Resources, Utah State University, Logan, UT 84322
Churchill, Derek, Forest Health Scientist, Washington Department of Natural Resources, Olympia, WA 98504
Hessburg, Paul, Research Landscape Ecologist, USDA Forest Service, Pacific Northwest Research Station, Wenatchee, WA 98801

Wildfire is the most important disturbance agent affecting forest landscape structure across the inland western United States. In recent decades, rates of annual area burned have outpaced restorative treatments across the region, and there is a need for more reliable models of fire severity and associated ecological impacts. Such tools would be useful for strategically focusing management efforts. We used remotely-sensed burn severity, topography, climate, and weather data to identify predictors of fire severity for 284 wildfires that burned in eastern Washington between 1985 and 2015. Our study domain included the Colville and Okanogan-Wenatchee National Forests.

We modeled fire severity as measured by remotely sensed burn severity indices derived from Landsat satellite imagery. We used machine learning, via random forest modeling, to 1) quantify variable importance of fire severity predictors, 2) examine the response functions of each predictor with respect to burn severity, and 3) evaluate relations between predictors and fire severity, and how they vary by topography, local climate and weather. We used principal coordinates of nearest-neighbor modeling (PCNM) and variance partitioning to reveal the strength of influence of spatial autocorrelation among our predictors and to help assess individual and shared variance components of our model predictors. Our results showed that severity was highest on shallow slopes, near ridgetops, and on north-facing slopes. Precipitation normals (30-year) were also influential. For example, higher summer season precipitation was associated with lower fire severity, while severity increased with winter snowfall. Likewise, hot and dry areas with low evapotranspiration rates were also associated with high severity. Non-linearities in variable response curves suggest possible multi-way interactions among predictors, indicating that relationships among predictors may vary in their primacy over both space and time.

Keywords: Fire Severity, Remote Sensing, Landsat, Fire History, Climate, Topography

Bio: Jonathan Kane is a research scientist working with the Precision Forestry Cooperative at the University of Washington. He specializes in remote sensing of forestry, with an emphasis on lidar. His past work includes remote sensing of fire in California, as well as using remote sensing to quantify habitat of spotted owls and pacific fishers.

149. Burn severity effects on multiple ecosystem recovery trajectories

Presenter: Beth Newingham, Research Ecologist, USDA Agricultural Research Service
Additional Author(s): Hudak, Andrew T., Research Forester, USFS Rocky Mountain Research Station
Bright, Benjamin C., Geographer, USFS Rocky Mountain Research Station
Smith, April G., Research Technician, USDA Agricultural Research Service
Henareh Khalyani, Azad, Research Scientist, Colorado State University

Burn severity is a term used to describe the longer-term, second-order effects of fire on ecosystems. Plant communities are assumed to recover more slowly at higher burn severities; however, this likely depends on plant community type and climate. We assessed vegetation recovery approximately a decade post-fire across North American forests (moist mixed conifer, dry mixed conifer, ponderosa pine) and shrublands (mountain big sagebrush and Wyoming big sagebrush) distributed across climate and burn severity gradients. We assessed vegetation recovery across these ecosystems as indicated by the differenced Normalized Burn Ratio derived from 1984-2016 Landsat time series imagery (LandTrendr). Additionally, we used field vegetation measurements to examine local topographic controls on burn severity and post-fire vegetation recovery. Ecosystem responses were related to climate predictors derived from downscaled 1993-2011 climate normals. We hypothesized that drier and hotter ecosystems would take longer to recover. We also predicted areas with higher burn severity to have slower recovery. We found post-fire recovery to be strongly predicted by precipitation with the slowest recovery in shrublands and ponderosa pine forest, the driest vegetation types considered. We conclude that climate and burn severity interact to determine ecosystem recovery trajectories after fire, with burn severity having larger influence in the short term, and climate having larger influence in the long term.

Keywords: burn severity, recovery, forest, shrubland, chaparral, climate

Bio: Dr. Beth A. Newingham, Research Ecologist, USDA-Agricultural Research Service. Dr. Newingham has contributed to wildland and prescribed fire research, education, and training in both academic and governmental settings. Her research focuses on post-fire ecosystem recovery and restoration in desert and forested ecosystems.

151. Incorporating Traditional Knowledge (TK) into Fire and Fuels Management

Presenter: Monique Wynecoop, Fire Ecologist, USFS
Additional Author(s): Morgan, Penelope, Professor, Department of Forest, Rangeland, and Fire Sciences, University of Idaho
Strand, Eva, Professor, Department of Forest, Rangeland, and Fire Sciences, University of Idaho
Sánchez-Trigueros, Fernando, Faculty Affiliate, Department of Geography, University of Montana

Evaluating fuel treatment effectiveness is challenging in tribal ancestral lands managed for multiple use. We sampled during and one growing season following the 2015 North Star Fire, which burned (218,000 ac of the Confederated Colville Tribal (CCT) ancestral territory. Participatory GIS was used to understand CCT member views regarding the location and effectiveness of fuel treatments within their ancestral territory within the CNF boundary. We measured the species richness and diversity of all plants and the canopy cover of six common culturally important plants on 30 plot pairs within areas treated and untreated prior to being burned by the North Star Fire. These post-fire monitoring results were consistent with PGIS results about management recommendations and desired outcomes of understory thinning, prescribed fire, and natural ignition. Integrating Traditional

Knowledge into fuels treatments can improve ongoing adaptive management of forests as social-ecological systems.
Understory vegetation diversity and six culturally important plants abundance were greater one year post fire within areas with broadcast burning and mechanical thinning fuel treatments compared to areas not subject to such fuel treatments prior to the North Star Fire. Our participatory GIS exercise was effective for getting public input. By bridging the gap between traditional knowledge and western science, we addressed a common challenge for managers and scientists trying to effectively manage socio-ecological systems. Our approach is potentially useful to forest managers planning fuels treatments and managing wildfires while bridging cultures in ancestral tribal lands. We hope the results from this project will be used by USFS managers in designing fuel treatments and for improving collaboration and trust between the USFS and local tribes that will help protect and promote tribal cultural use of their traditional hunting, fishing, and gathering areas.

Keywords: Fire Effects, Northeastern Washington, Participatory Geographic Information Systems, Social Ecological Systems, Traditional Knowledge

Bio: Monique is a Fire Ecologist for the Colville National Forest. She received her MS Degree from the Department of Forest, Rangeland, and Fire Sciences at the University of Idaho in 2017. She also received her dual major in Ecology and Conservation Biology and Fishery Sciences and a minor in American Indian Studies at UofI in 2010. She is Mountain Maidu and her husband and children are Spokane Tribal members. Her research is inspired by her family and the cultural importance of their ancestral homelands. She has a passion for promoting improved cross-boundary collaboration to address landscape scale resource management challenges.

152. A Quarter Century of Change in Wildland Fire Science

Presenter: Susan Conard, Editor-in-Chief, International Journal of Wildland Fire
Additional Author(s): Doerr, Stefan, Professor, Swansea University, Wales, U.K.
Foster, Jenny, Publisher, International Journal of Wildland Fire, CSIRO Publishing, Australia

Over the past several decades wildland fire research in many countries has expanded rapidly in scope and complexity in response to environmental and societal changes. In many regions of the world fire has increasingly been recognized as an important ecosystem process, rather than something that must always be prevented or suppressed. Concerns have increased over how to manage the negative impacts of fire on infrastructure and human health, while balancing the often-positive values of vegetation fires. Researchers and managers have learned more about fire regimes and how and why they are changing. Especially over the past couple of decades recognition of the regional and global importance of the interactions between fire and climate—and the role of these interactions in ecosystems and society--has grown. But there is much yet to learn. Over the same period, ideas on how to manage fire have changed, and new tools have been needed and are being developed to support improved decision-making and cost-effectiveness of fire and fuels management. This talk will discuss evolution of fire research programs and products over the last 25-30 years, with examples from North America and other selected regions of the world. These changes can be viewed through the lens of changes in types and numbers of wildland fire publications. The International Journal of Wildland Fire, first published in 1991, has grown and evolved in response to the expansion of research programs and management interests. Over the same period, fire has become an increasingly prominent topic in many other journals. We will look at the increases and changes in emphasis of fire research publications over that period, discuss how the

outlets for fire research have changed over time, and suggest how we might expect fire research to change in the future.

Keywords: fire research, wildland fire, climate change, fire management

Bio: Dr. Conard has been co Editor-in-Chief of the International Journal of Wildland Fire since her retirement from the US Forest Service in 2008. She has conducted research in wildland fire effects since the early 1970's, primarily in California and in Siberia. From 1996 until her retirement she was National Program Leader for Fire Ecology Research in the US Forest Service Washington Office. She is currently an Emeritus scientist with the Rocky Mountain Research Station, and holds an affiliate faculty position at George Mason University.

153. Periodic changes in wildland fire research

Presenter: Pil Sun Park, Professor, Seoul National University
Additional Author(s): Hyung Jung Kim, Researcher, Baekdudaegan National Arboretum
Jong Bin Jung, Gradnate student, Seoul National University

Wildland fire is deeply connected to scientific, social and political interest because it can easily threaten lives and destroy assets, making wildland fire one of most important topics in forest and wildland research and management. We chronologically analyzed research topics on wildlife fire using journal database from 1900. The major topics on wildland fire research before 1970 was fire policy, preparedness, firefighting, fire weather, fire impact and fire statistics. Establishment of wildland fire governance and fire control were main issue until 1960s. Scientific research on wildland fire became active since 1970s. The cumulative number of journal publications upto 1970 was similar to the number of journal publications in 1970s. Number of fire research published in journals showed linear increase from 1970 to 1990 and the topics became more diverse and detailed. Post-fire effects on vegetation and soil were actively studied in 1970s. The number of papers on wildland fire doubled in 1980s compared with that in 1970s. Post-fire effects were studied in diverse aspects including plants, regeneration, soil, nutrition, catchment and wildlife. Fire modeling began to get interest in 1980s. The development of RS and GIS techniques and internet drastically changed the wildland fire research conditions in 1990s. Fire management techniques based on RS or GIS techniques and fire modeling were major research topics on wildland fire in 1990s and 2000s. Climate change has been a dominant issue in wildland fire research and management since 2000s. Research on human impact on wildland fire and post-fire restoration also increased since 2000s. With the increase in transportation and information transfer technology, news on wildland fire expand more quickly and farther than before, putting wildland fire closer to society. Thus, research on wildland fire becomes more connected to social issues. The topics on wildland fire research have been changed with the social and technical development.

Keywords: Wildland fire research topic, chronological analysis, periodic change, wildland fire techniques, fire management

Bio: Pil Sun Park is a professor of silviculture and forest ecology in Seoul National University in Korea, and has been studied in the relationship between wildland fire and stand structure.

154. Research, Data, and Tools to Support Wildland Fire Challenges
Presenter: Paul Steblein, Fire Science Coordinator, U.S. Geological Survey
Additional Author(s):

Wildfires are expensive, dangerous, and have massive impacts on people (smoke, water supply systems, economic uses - timber, grazing, hunting/fishing, recreation) – yet wildland fire is essential in many fire-adapted ecosystems across the country. Wildland fire science from the U.S. Geological Survey (USGS) has provided managers with knowledge, data and tools to manage fire, but emerging patterns leave managers ill-equipped to deal with the new challenges. Scientists at USGS produce research, data and tools that are used by fire and land managers before, during and after wildfires. USGS' niche for fire science is driven by its legacy support on biological science for DOI administered lands, national mapping and remote sensing (satellites & geospatial tools), geology and water science (landslides and flooding). The four primary areas of science include 1) wildland fire behavior, risk assessment, and risk reduction; 2) fire effects and restoration; 3) post-fire risk assessment and reduction; and 4) remote sensing/geospatial tools and data. Scientists at USGS collaborate with other scientists at federal agencies, universities and other science organizations to meet the information needs that are critical to communities, states, and fire/land managers. The USGS is developing a strategic plan for wildland fire science, which will be described. Input is sought from stakeholders on priority science needs to meet the emerging challenges of wildland fires.

Keywords: Science supporting wildland fire management

Bio: Early in his career, Paul Steblein served as a scientist with the N.Y. Biological Survey, then joined U.S. Fish and Wildlife Service to establish a GIS/Data Center for the northeast region. He has since served in the National Wildlife Refuge System at refuges around the country and in headquarters addressing a multitude of difficult natural resource issues, including wildland fire. Paul recently joined U.S. Geological Survey (USGS) from the Department of the Interior Office of Wildland Fire where served as Deputy Director Policy and Budget and sat on the Governing Board of the Joint Fire Science Program. At the USGS, Paul is working with scientists and stakeholders to develop and implement a fire science program.

155. Building shared solutions to global climate-fire issues, from Africa to home.
Presenter: Ron Steffens, Professor of Communications, Green Mountain College
Additional Author(s): Chappell, Linda, Intermountain Region fuels program manager, USFS.
Lata, Mary, fire ecologist, Four Forests Restoration Initiative Team, USFS.
DiPietro, Marlene, range planning specialist, USFS retired.

GOAL: To share insights learned from fire ecology and fire management training missions in Africa, and to explore next steps for successful global fire training missions, and to discover commonalities of fire management that global fire trainers bring back to their home units.

STRUCTURE: Fire ecologists, planners, trainers and managers who have staffed USAID/US Forest Service-International Programs to Africa will share what we've learned, identify future mission priorities, and offer guidance on how to apply your skills in international fire training missions. Trainers from prior missions to Africa will reflect on how international training experiences can create a shared vision of community-focused fire management that can be applied locally as well as globally.

FOCUS: From the tropics and sub-tropical savannah zone of the Congo River to the miombo forests in east-central Africa, changes in land use, fire use and climate are impacting community resilience and in turn impacting ecological resilience. The US Forest Service-International Programs with USAID support have supported a range of fire management and land use planning missions to the Republic of Congo, Democratic Republic of Congo, and Malawi. These missions adapt US-focused fire management and land use planning expertise to new landscapes, communities and fire challenges – and bring home lessons that change our own approach to fire management in the US. A range of fire mission participants will share what we've learned and discuss the process of change, both in the way fire is managed to meet new challenges, and in how traditional fire use can inspire fire management in the climate-change era, regardless of which village you call home.

The mini-presentations will focus on lessons learned regarding fire training, fire planning and fire ecology from missions in Africa, specifically to Malawi, Democratic Republic of Congo (DRC), Republic of the Congo (ROC).

The second half of the presentation will transition to dialogue, where presenters and audience will:

(A) Identify future needs for global training in terms of staffing, leadership, common training materials, and a template for recruiting and training mission staff.
(B) Discuss future mission options for those who have not served on an international mission or who wish to serve again.
(C) Explore the role that such missions play in developing shared international wildfire expertise, which in turn supports an engaged and adaptable fire management community that is valid locally and globally.

Keywords: Africa, international training, climate change, community fire planning

Bio: Key presenters include fire trainers with experience in Malawi, Democratic Republic of Congo, and Republic of Congo. Ron Steffens — professor of communications, managing editor of Wildfire Magazine, and incident commander/fire analyst with Grand Teton National Park (summers). Linda Chappell — Intermountain Region fuels program manager, USFS. Mary Lata — fire ecologist, Four Forests Restoration Initiative Team, USFS. Marlene DiPietro — range planning specialist, USFS retired. Other speakers may join the roundtable.

156. Preparing Tomorrow's Fire Professionals: Opportunities for Mentoring, Field Trips and Training

Presenter: Steven Miller, Chief, Bureau of Land Resources, St. Johns River Water Management District
Additional Author(s): Stowe, Johnny, Heritage Preserve Manager, South Carolina Department of Natural Resources, Address: PO Box 23205, Columbia, SC 29224
Zachary Prusak, Florida Fire Manager and Central Florida Conservation Program Manager, The Nature Conservancy

Wildland fire careers are more complex than they use to be. The wildland fire community loves to use triangles to describe the challenges we face. There is the fire triangle (fuel, heat, oxygen), the fire behavior triangle (fuels, weather, topography), and previous authors have suggested there is the fire career development triangle (education, training, experience). Today more than ever, wildland fire professionals require strength in all three legs of this fire career development triangle. Around the country there are several established and developing models in which established fire professionals work with people beginning their fire careers to help strengthen the training and experience legs of the newcomer's fire career triangles. One of the most interesting things is that these relationships between established professionals and the newcomers are symbiotic. The established professionals derive many benefits as well.

Keywords: Training, TREX, career development

Bio: Steve "Torch" Miller earned a BS in Forest Administration from the University of Wisconsin Stevens Point and an MS in Ecological Restoration from the University of Florida. He has worked for a private forestry consultant, the USFS, Texas Forest Service, and Florida Division of Forestry and is currently the Chief of the Bureau of Land Resources for the St. Johns River Water Management District. Steve is responsible for directing a multiple use land management program on over 600,000 acres. Steve has experience in both prescribed fire and fire suppression. He is an RXB1 and serves as Deputy Incident Commander on the Florida Red Overhead Team. He recently received the Excellence in Fire Management Award from the IAWF. He is married and the father of two; one of whom is a second-generation forester and fire manager.

157. Observations of fine-scale moisture dynamics and flammability in pine and oak litter: Solar heating, fuel position, and species all matter

Presenter: Jesse Kreye, Research Scientist, University of Washington
Additional Author(s): Hiers, Kevin, Wildland Fire Scientist, Tall Timbers Research Station
Varner, Morgan, Research Biological Scientist, USDA Forest Service
Kane, Jeffrey, Associate Professor, Humboldt State University

Surface fire behavior is often spatially and temporally heterogeneous, resulting from fine-scale patterns of fuel characteristics and moisture content. The source of this fine-scale variation is likely driven by a combination of fuelbed characteristics and forest structure. Surface-fuel exposure to solar radiation, affected by forest structure, is expected to influence both fuel temperature and fuel moisture, both anticipated to impact fire behavior. We observed through a suite of laboratory and field-scale experiments that direct solar radiation exerted a strong influence on patterns of fine dead fuel moisture. Oak (Quercus stellata and Q. falcata) litter reacted much more readily to environmental conditions than did pine (Pinus palustris) litter, resulting in sizeable differences in fuel moisture between species. And elevating pine litter, simulating suspended fuels, also influenced moisture dynamics. The effects of infrared radiation on flammability of pine and oak litter were also revealed through laboratory burning experiments. Radiation exposure increased litter flammability, but results were primarily driven by impacts of radiation on fuel moisture loss. Trends were similar for both species. While radiation increased fuel temperatures by as much as 25 °C, the role of solar heating in forest floor moisture dynamics and litter flammability may be key for understanding its impacts on variability of fire behavior. Understanding spatial and temporal heterogeneity of fire behavior resulting from surface fuelbed and overstory characteristics may be important for meeting prescribed burning objectives.

Keywords: fire behavior, fuel hetereogeneity, fuel moisture, fuel temperature

Bio: Jesse Kreye is a Research Scientist in the School of Environmental and Forest Sciences at the University of Washington. He works with the Fire and Environmental Research Applications Team at the US Forest Service's Pacific Wildland Fire Sciences Lab in Seattle, WA.

158. Upslope fire and eruptive fire

Presenter: François Joseph Chatelon, Associate Professor, University of Corsica
Additional Author(s): Balbi, Jacques-Henri, Emeritus Professor, UMR-CNRS SPE 6134 University of Corsica
Marcelli, Thierry, Associate Professor, UMR-CNRS SPE 6134 University of Corsica
Rossi, Jean Louis, Associate Professor, UMR-CNRS SPE 6134 University of Corsica

This work deals with a fire spreading upslope under either no-wind conditions or weak wind velocities.
The surface fire propagation model developed at the university of Corsica is used, which takes into account convective and radiative effects. The Rate of Spread (ROS) is defined as an algebraic function of the wind velocity, terrain slope angle and fuel characteristics.
The model is based on the coupling of the own properties of the spreading fire with other conditions (wind, topography) and consists in a feedback effect caused by the flow induced by the fire in the presence of a positive slope. This flow, which is called 'induced wind' is modelled thanks to a mass balance in the flame. It appears to be proportional to ROS.
The expression of this induced wind, coupled to the propagation model gives an algebraic relationship for the ROS which depends on the terrain slope angle. When the terrain slope angle increases, the ROS weakly but steadily increases up to a threshold slope angle. Beyond this threshold, the ROS reaches very important values and then the fire behavior turns to an eruptive fire. The coupling ROS/slope angle provides exactly this change in the fire behavior. Nevertheless, for operational matters, the main goal consists in obtaining very simple conditions necessary to eruption triggering.
A simplification of the ROS relationship leads to a triggering condition which only depends on fuel characteristics and the threshold slope angle.
The physical interpretation is closely attached to the definition of the induced wind. Below the eruptive condition, the induced wind is limited and so is the ROS. Beyond that condition, an increase of the induced wind causes an increase of the ROS which leads to an increase of the induced wind. Without any change in the fuel or slope conditions, this feedback leads to huge values of the ROS, which involve the visual impression of a generalized blaze flash.

Keywords: Surface fire - Propagation model - Eruptive fire - Conditions of eruption

Bio: Francois Joseph Chatelon has been doctor of applied mathematics since 1996. He has been a member of the fire research team of the University of Corsica since 2007. He currently works on physical modelling of fire behaviour and eruptive fires.

159. Examining the Terminal-Velocity Assumption in Simulations of Long-Range Firebrand Transport

Presenter: Christopher Thomas, , University of New South Wales, Australia
Additional Author(s): Sharples, Jason J, Associate Professor, UNSW Australia, Canberra.
Evans, Jason P, Professor, Climate Change Research Centre, UNSW Australia.

Firebrand transport and subsequent spot-fire development is an important mechanism of fire propagation, particularly in extreme conditions. Early modelling of firebrand transport (eg Tarifa el al, 1967) used a combination of experimental and analytical work with some simplifying assumptions. One of these is the so-called terminal-velocity assumption, in which a firebrand is assumed to always fall at its terminal velocity with respect to the wind field. With the advent of high-speed computers,

more elaborate systems of equations of motion can be solved numerically to model firebrand transport, and the terminal-velocity assumption has become less important. However, eschewing the terminal-velocity assumption adds computational cost and it is sometimes still used.

Koo et al. (2012) have modelled surface fire using a high-resolution coupled atmosphere-fire model and showed that simulations of short-range firebrand transport using the terminal velocity assumption underestimated firebrand travel distances substantially when compared with simulations in which the assumption was not made. More recently, Thurston et al. (2017) used a strong form of the terminal-velocity assumption to study long-range firebrand transport in turbulent plumes using a large eddy simulation (LES) model.

We report on a study in which we examined the validity of the terminal-velocity assumption in modelling the long-range transport of inert firebrands in turbulent plumes. Like Thurston et al (2017), we did not model the effects of firebrand combustion. The Weather Research and Forecasting (WRF) model was used in LES mode to simulate a plume in a turbulent boundary layer. Using the simulated wind field, the transport of firebrands was modelled under various assumptions, and the results were compared. It was found that the use of the terminal-velocity assumption overestimated both maximum firebrand transport distances and long-range landing densities compared with simulations in which the assumption was not made.

Koo, E., R. R. Linn, P. J. Pagni, and C. B. Edminster (2012). Modelling firebrand transport in wildfires using HIGRAD/FIRETEC. International Journal of Wildland Fire 21(4), 396-417.

Thurston, W., J. D. Kepert, K. J. Tory, and R. J. B. Fawcett (2017, May). The contribution of turbulent plume dynamics to long-range spotting. International Journal of Wildland Fire 26(4), 317-330.

Tarifa, C. S., P. P. del Notario, F. G. Moreno, and A. R. Villa (1967). Transport and combustion of firebrands. Technical report, Instituto Nacional de Tecnica Aeronautica, Madrid.

Keywords: Firebrand transport, spot fires, terminal velocity assumption

Bio: Christopher Thomas is a PhD student studying under Associate Professor Jason Sharples at the University of New South Wales, Canberra, Australia. Prior to this he worked at Geoscience Australia, modelling the effects of natural hazards such as tsunamis, earthquakes and extreme winds. He has published in the fields of applied mathematics, geodesy, natural hazards, and wildfire research. He has a master's degree in mathematics from the University of Chicago.

160. Understanding Ignition: How One Spark Can Burn an Entire Forest
Presenter: Erik Christiansen, Principal Engineer, Exponent, Inc.
Additional Author(s): James Karnesky, Ph.D., P.E., C.F.E.I., Managing Engineer, Exponent, Inc.

Understanding how a fire starts is an essential element of fire prevention and management. The ignition of wildland fuels is an especially complex phenomenon owing to the wide array of fuels found on the floor of a forest, from pine needles to twigs to downed, decaying trees, as well as their irregular shape and arrangement. Fuel moisture, ambient temperature, and wind are among the various environmental conditions that can make the difference between a spark fizzling out or igniting a conflagration. This presentation will give an overview of the factors that influence whether ignition is possible, with a focus on the role of heat transfer between the ignition source and the fuel. Recent experiments conducted by the authors compare the incendivity of molten droplets of aluminum with that of hot particles of borosilicate. Despite both media having essentially the same mass and total energy, the aluminum droplets were more likely to ignite fuels than the glass particles. Observations from the testing show that the molten aluminum would flow when contacting the surface of the fuels, allowing it to conform to surface irregularities typical of wildland fuels. This effect results in efficient conductive heat transfer to the fuel, whereas a solid particle may lose heat to void spaces within the fuel bed. Consequently, the incendivity of a potential ignition source is not directly correlated with its available thermal energy; instead, it is its capability to transfer that energy to the fuel that drives ignition.

Keywords: wildland fire, ignition, heat transfer

Bio: Erik Christiansen, Ph.D., P.E., C.F.I., is a Principal Engineer in the Thermal Sciences practice at Exponent, Inc. He specializes in fire science, combustion chemistry, fluid mechanics, thermodynamics, and heat transfer. He performs origin and cause investigations of fires and explosions, ranging from small residential fires to large-scale industrial incidents to multi-acre wildland fires. Dr. Christiansen has conducted testing and research on the ignition of wildland fuels by various causes and has over fifteen years of experience investigating fires and explosions.

161. Dynamic changes of forest fire in China and fire drivers in different forest ecosystems
Presenter: Futao Guo, Associate Professor, Fujian Agriculture and Forestry University; University of Washington
Additional Author(s): Su, Zhangwen; PhD, Fujian Agriculture and Forestry University
Wang, Guangyu, Professor, Associate Dean of Faculty of Forestry, UBC
Hu, Haiqing, Professor, Northeast Forestry University
Tigabu, Mulualem, PhD, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre.

In this study, the spatio-temporal distribution of forest fires in China from 2000 to 2015 was studied based on two data sources (official records and satellite data) and the dynamic changes of forest fire frequency and burned area were identified. The results show that the distribution of forest fires is spatially uneven in China. The fire density showed an overall upward trend but did not change significantly in Northeastern China; however, at the same time, the overall burned area remained stable, which is considered to be related to China's strict forest fire prevention and control policy. In addition, in order to further reveal the factors that cause the variation of forest fires characteristics in China, the spatial patterns and driving factors of fires were identified using Ripley's K (d) function and logistic regression (LR) model in two different forest ecosystems of China: the boreal forest

(Daxing'an Mountains) and sub-tropical forest (Fujian province). Relative effects of each driving factor on fire occurrence were identified based on standardized coefficients in the LR model. Results revealed that fires were spatially clustered and that fire drivers vary amongst differing forest ecosystems in China. Fires in the Daxing'an Mountains respond primarily to human factors, of which infrastructure is recognized as the most influential. In contrast, climate factors played a critical role in fire occurrence in Fujian, of which the temperature of fire season was found to be of greater importance than other climate factors. Selected factors can predict nearly 80% of the total fire occurrence in the Daxing'an Mountains and 66% in Fujian, wherein human and climate factors contributed the greatest impact in the two study areas, respectively. This study suggests that different fire prevention and management strategies are required in the areas of study, as significant variations of the main fire-driving exist. Rapid socio-economic development has produced similar effects in different forest ecosystems within China, implying a strong correlation between socio-economic development and fire regimes. It can be concluded that the influence of human factors will increase in the future as China's economy continues to grow - an issue of concern that should be further addressed in future national fire management.

Keywords:

Bio: Dr. Futao Guo is Associate Professor at College of Forestry, Agriculture and Forestry University, China. He studied and worked at State University of New York and University of British Columbia for a couple of years and currently working at University of Washington as a Visiting Scholar. His main research interests include forest fire management, forest fire ecology and forestry modeling. He sponsored about ten projects funded by Chinese governments and also closely collaborated with other international organizations such as APFnet and institutes in UBC and UW. He had 40 publications related to forest fires in the past five years.

162. Flammability Characteristics of Common Garden Litter under FPL Instrumented Hoods

Presenter: Mark Dietenberger, Research General Engineer, USDA Forest Service - Forest Products Laboratory
Additional Author(s): Dickinson, Matthew, Research Ecologsit, US Forest Service
Boardman, Charles, General Engineer, US Forest Service - Forest Products Laboratory

Over large areas of mixed-oak forest in the eastern US, oaks are being replaced by more mesophytic species. Fire suppression figures prominently in this forest change and forest compositional shift may complicate the reintroduction of fire for oak ecosystem management if fuel beds become more difficult to burn and burn less intensely. A common garden fuels experiment with replicated plots of oak, maple, and mixed oak and maple litter distributed among topographic positions over an Ohio Hills landscape provided the fuels for examination. Samples of intact litter packing on the clay substrate were retrieved from randomized sites. They were cut down to 100mm by 100mm, conditioned at 30% RH at 70F for extended periods, and then tested in the Cone Calorimeter (ASTM E1354-11a) under irradiance of35 kW/m2 with piloted ignition. Subsamples were analyzed for extractives, sugar, lignin, and ash. Flammability information such as time to ignition, peak heat release rate, total heat release, average heat of combustion, and smoke production provided indications for difficulty of burns in the field, and can provide prognostication for future burns, as varying with field conditions, species, and composition. Remaining physical attributes were measured to provide an indication of flame spread using Rothermal model [1]. Measurement of temperatures on the surface layer, the litter/substrate interface, and substrate base along with water vapor flow measurements has demonstrated the importance of moisture flow and thermal inertia within the specimen that are overlooked in flame spread models, including Rothermal model, but can be features to be predicted in a detailed fuel and fire model. Samples of fresh and weathered loose litter were also retrieved to provide fuel in a chicken wire basket under FPL's HRR hood and ignited with a flaming sublayer of methanol soaked absorbent paper on a pan, or with natural gas burner, depending on results desired. They were tested under the HRR hood with enhanced gas, particle and flow measurements that provided important combustion information such as efficiency and radiant fraction along with emission and water vapor production characteristics that will be suitable for detailed fire modeling, and as a laboratory basis for remote sensing methods.

[1] Dickinson, M.B.; Hutchinson, T. F.; Dietenberger, M.A.; Matt, F.; Peters, M.P.; Yang, J., Litter Species Composition and Topographic Effects on Fuels and Modeled Fire Behavior in an Oak-Hickory Forest in the Eastern USA, PLOS ONE, Vol. 11(8): e0159997-.

Keywords: litter flammability, enhanced cone calorimetry, instrumented fire hood, vegetation fuel propeties, Rothermal fire spread

Bio: Dr. Dietenberger is focused on fire safety and building science research at Forest Products Laboratory. Wide ranging capabilities include from developing fire and moisture test methods to using and developing advanced fire models. He has developed the ecoSmart Fire Model to evaluate and plan for vegetative landscaping around the home. The Fire Dynamic Simulator was used and improved to model room flashovers for wood based linings and for fire development on decking materials under the instrumented hood for heat release measurements. He has developed fire testing methods for the forest litter and live wildland fuel to provide fuel properties for detailed fire modeling, such as WFDS.

163. Wilderness Fire Management: Harder Then or Now?

Presenter: Vita Wright, Social Science Analyst, Rocky Mountain Research Station
Additional Author(s): Miller, Carol, Research Ecologist, Aldo Leopold Wilderness Research Institute

The U.S. Forest Service's Wilderness Fire Program began in the 1970s in the Selway-Bitterroot and Bob Marshall Wildernesses in the Northern Rocky Mountains. In a culture dominated by fire suppression and the 10 A.M. Policy, early managers navigated uncharted political territory to pioneer wilderness fire management and, ultimately, the Wildland Fire Use Program. We interviewed wilderness fire pioneers and current managers about challenges and successes around wilderness and long-duration fire management. Next, we convened a workshop in the Bob Marshall Wilderness with past and present wilderness fire managers and decision makers to discuss past, present, and future challenges. Using 1988, 1994, 2000, and 2009 as turning points in Northern Rockies fire management within the context of environmental conditions, organizational culture, and capacity to manage fire, we share insights from the interviews and workshop discussions to address the question, "Was it harder then or now?"

Keywords: wilderness fire

Bio: Vita Wright has spent 20 years as a Science Application Specialist with the USDA Forest Service's Rocky Mountain Research Station. For the past seven years, she has led planning and implementation of the Joint Fire Science Program's Northern Rockies Fire Science Network. In addition to delivering science, she conducts research on individual and organizational influences on the communication and use of fire science for fire and fuels management by agency managers. She holds an M.S. in organismal ecology and a PhD in the human dimensions of forestry from the University of Montana.

164. Tree Clump and Opening Patterns Following Wildfire: Comparing Managed and Wilderness Areas

Presenter: Haley Wiggins, Research Analyst, Precision Forestry Cooperative, Research Laboratory, University of Washington
Additional Author(s): Kane, Van R., Research Associate Professor, University of Washington
Kane, Jonathon T., Research Scientist, University of Washington
Bartl-Geller, Bryce N., Research Analyst, University of Washington

Wildfire suppression has homogenized forest structure in dry, low-to-mid elevation coniferous forests across the western US, increasing vulnerability to wildfires, drought, disease, and insects. Structural heterogeneity promotes resiliency to such threats, and variation in fine-scale structure (i.e. spatial pattern) is particularly important for disturbance recovery and ecosystem function. Spatial pattern in landscapes with intact fire regimes is characterized by individual trees and tree clumps (typically small clumps) interspersed with frequent canopy openings, however, the effects of mixed severity fires on spatial pattern across large areas and management legacies are poorly understood. In this study, we assess the effects of burn severity on post-fire clump and opening distributions, and compare these effects in wilderness (Yosemite National Park; YNP) versus managed (Tahoe National Forest; TNF) landscapes. We began our investigation by developing methods for quantifying spatial pattern at landscape scales, using trees identified from airborne LiDAR data in an ICO (Individual trees, Clumps of trees, and Openings) framework. Within YNP and the TNF, we identified areas that burned recently for the first time in the modern fire record, and adjacent areas that have experienced no recorded fire. We also quantified reference ICO conditions based on YNP areas that have experienced at least two recorded fires and that burned at low- to moderate-severity in the most recent fire. Example ICO metrics include the relative frequency of individual trees, small clumps (2-4 trees), and larger clumps (5-9 trees), and the total area in canopy openings. As expected, burn severity in both YNP and TNF recent fires was negatively correlated with large tree clump frequency and positively correlated with area in canopy openings. However, clump and gap size distributions were similar between YNP and TNF recent fires for low and moderate burn severities but very different for high burn severities. In general, similarity in spatial pattern metrics between recently burned areas and the reference condition was strongly affected by burn severity on the TNF, while burn severity had limited effect in YNP. For example, niche (distribution) overlap of large clump frequency in recently burned areas versus reference areas ranged from 0.3 to 0.8 (from low to high severity) on the TNF but remained constant at about 0.9 across burn severities in YNP. Our findings demonstrate differential effects of burn severity on post-fire structure and pattern in mixed-conifer forests of wilderness versus managed landscapes.

Keywords: LiDAR, forest structure, burn severity, spatial pattern

Bio: As a Research Analyst with the Pacific Forestry Cooperative Research Laboratory at the University of Washington, Haley uses airborne LiDAR to study forest structure, spatial pattern, and fire effects across large landscapes. She recently completed her Master's at the W.A. Franke College of Forestry and Conservation, University of Montana. For her thesis, she developed methods for using LiDAR to characterize structural reference conditions at fine, medium, and coarse spatial scales. Haley's career interests include ecological restoration, fire ecology, and forest management.

165. Forest structure, fuel loads, and successional pathways following single and repeat fires in mixed-conifer forest

Presenter: Andrew Larson, Associate Professor, University of Montana
Additional Author(s): Belote, R. Travis, Senior Research Ecologist, The Wilderness Society, 503 W. Mendenhall, Bozeman, MT 59715, USA

Wilderness areas offer scientific value to society by providing opportunities to investigate effects of large natural disturbances, including wildfire. Since the early 1980s managers have allowed many lightning-ignited fires to burn with minimal interference in forests of the Bob Marshall Wilderness in northwestern Montana, USA. Substantial portions of this landscape burned twice between 1985 and 2015. We used this active fire regime to investigate fire-effects and post-fire fuel loads, tree regeneration, and forest structure in mixed-conifer forest communities. Short-interval reburns decreased surface fuel loads relative to once-burned and unburned sites. While total woody surface fuel loads were decreased by repeat fires, black carbon—the carbon fraction of charcoal—on woody debris was approximately twice as abundant in twice-burned patches compared to once-burned patches. Reburns decreased tree seedling density relative to once-burned sites, but we found limited evidence of widespread transitions to non-forest communities. Reburns of sites that burned in an initial high-severity fire had the lowest surface fuel loads and lowest live tree and seedling densities. These mixed-conifer forests appear highly resilient to repeated wildfires. Succession back to closed-canopy, high-biomass forests will likely be much slower in reburns compared to once-burned sites. Nevertheless, most twice-burned sites appear to be on a trajectory back to tree-dominated conditions, although via different successional pathways compared to once-burned forests.

Keywords: wilderness, fire effects, reburn, fuel, black carbon, succession

Bio: Dr. Andrew J. Larson is Associate Professor of Forest Ecology at the University of Montana. His research examines disturbances and dynamics of forest ecosystems, including implications for forest restoration and management strategies for climate change adaptation and mitigation. He earned degrees in forestry (BS) and ecosystem analysis (PhD) at the University of Washington. Dr. Larson teaches courses in forest ecology, disturbance ecology, and silviculture. He currently serves as Associate Editor for the journal Fire Ecology.

166. Severity of Short-Interval Reburn Mediates Compositional Shifts in Fire-Adapted Montane Shrublands

Presenter: Deborah Nemens, Research Scientist, University of Washington
Additional Author(s): Varner, Julian M., Team Leader and Research Biological Scientist, USDA Forest Service Pacific Northwest Research Station
Kidd, Kathryn R., Assistant Professor of Forest Resources Management, Stephen F. Austin State University
Kreye, Jesse K., Research Scientist, University of Washington

Montane chaparral is a shrub community dependent on fire for its persistence in areas where it intergrades with the dry mixed-conifer forests of northern California. In these fire-prone regions, irregular patterns of mixed-severity fire on the landscape historically created forest gaps and clearings where shrublands could persist. Decades of fire exclusion facilitated the invasion of conifer forests into these gaps, reducing the extent of shrub-dominated ecosystems. Recent evidence exists that large, stand-replacing wildfires may be reversing this trend in some areas. Previous studies have documented vegetative type-conversion from mixed-conifer forest to chaparral occurring where

high-severity fires occur. These state shifts are especially persistent in short-interval reburn areas, where conifer regeneration is often limited, and post-fire strategies of chaparral species enable shrub dominance. Regeneration mechanisms of chaparral species are often broadly grouped into a) species that rely on soil seed banks for post-fire germination and b) species that store carbohydrates in underground structures to facilitate post-fire sprouting. While burn severity- and interval-dependent vegetative shits are well studied, little attention has been given to the effects of these disturbance characteristics on the species composition of subsequent plant communities. In order to assess the effects of differential severities on these groups, we examined shrub abundance and species composition across a spectrum of burn severity combinations in a 9,000 ha reburn area with a 12-year interval between wildfires in the Lassen National Forest, CA. Species with the capacity to resprout after stand-replacing wildfire were advantaged over those that depend on fire-cued germination from latent seedbanks after two high-severity burns, while the latter group dominated stands with higher burn severity in the reburn fire. Our results indicate that post-reburn vegetative reponse is not only interval-dependent, but varies with combined burn severity following reburns. The findings have implications for future fire behavior and landscape heterogeneity and resilience in the context of a warmer and drier climate in California.

Keywords: reburn, montane chaparral, fire interval, post-fire regeneration

Bio: Deborah was recently awarded a Master's degree in forestry with a focus in fire ecology from the University of Washington. Here career has spanned the fields of restoration ecology, botany, land management, and fire science. Her research interests include the effects of fire on vegetation, conservation of fire-dependent species and habitats, and the use of prescribed fire as a restoration tool in degraded ecosystems.

167. Ecoregional differences in reburn patterns of California wildfires
Presenter: Jeffrey Kane, Associate Professor, Humboldt State University
Additional Author(s): Wright, Micah, Research Associate, Humboldt State University
Greene, David, Professor, Humboldt State University

Climate-induced increases in wildfire frequency and size in much of the western U.S. have prompted concerns by fire scientists and managers about the potential negative impacts of short-interval, repeat burning ('reburn' fires). We therefore expect that the frequency and size of reburn fires may also be increasing. However, given that a relatively small proportion of area that burns annually (i.e. return times are long), we expect that reburns would represent relatively rare events. We used an existing dataset on large fires (> 400 ha) in California from 1984-2015 from the Monitoring Trends in Burn Severity program to examine the following questions: 1) Does the proportion of reburn area differ among ecoregions?, and 2) Has the pattern of reburn increased over time across all ecoregions? Based on our preliminary analysis, we found that reburn area over this 31-year period represented a relatively small proportion of burnable areas across California (<1%). The proportion of area that reburned ranged widely from <0.5% to 5%, with reburn area in the southern California coast and the Klamath Mountains having greater proportions than other ecoregions. For five of the thirteen California ecoregions the size and total reburn area has significantly increased over time, while the other regions did not have a clear trend. Given the relatively low proportion of reburn area across California, concerns for potential negative effects may currently be overstated. Yet, the proportion of reburn area is increasing in some ecoregions and there still may be local areas where reburns reflect higher frequency or severity than characteristic of the historical fire regime. Further analysis will examine patterns of frequency and severity in reburn fires by ecoregion and potential factors that may explain observed differences among ecoregions.

Keywords: repeat fires, wildfire, reburn, climate change

Bio: Jeff Kane is originally from upstate NY where he received his BS at Plattsburgh State University. After six years working as a technician for non-profit organizations and governmental agencies on various fire research, restoration, and management projects, he received his MS from Humboldt State University in 2008 and continued on to a PhD at Northern Arizona University. Currently he is an Associate Professor and Director of the Wildland Fire Lab at Humboldt State University. His research broadly focuses on providing information to better manage, restore, and conserve fire-prone ecosystems in an era of rapid change.

169. ChaRoFlux: a novel metric that links fire-intensity to its effects on ecosystems

Presenter: Claire Belcher, Professor (Personal Chair) of Earth System Science and Director of the wildFIRE Lab, wildFIRE Lab, University of Exeter
Additional Author(s): New, Stacey, wildFIRE Lab, University of Exeter
Grosvenor, Mark, Dr, wildFIRE Lab, University of Exeter
Hadden, Rory, Senior Lecturer in Fire Investigation, University of Edinburgh
Gallagher, Michael, Research Technician, USFS Northern Research Station
Skowronski, Nicholas, Dr, Research forester, USFS Northern Research Station

Prescribed burning is increasingly being used successfully to reduce fuels and restore fire disturbance to landscapes that historically experience wildfire, with the aim being to mimic natural fires. However, the extent to which prescribed fires recreate the effects of historical fire regimes is hotly debated. Prescribed fires often differ in terms of their timing relative to phenology (e.g. timing of plant growth) and in their intensity (energy output) when compared to the natural fire season and fire behaviour. The latter in particular has been shown to exert a strong influence on ecosystem effects, such that their influence on understory regrowth and tree mortality can vary considerably.

Fire intensity encompasses a range of factors that are not readily quantifiable, either during or after a fire event. This has left wildland managers with a long-standing need to find a means to generate predictive tools that allow them to link the behaviour of fires to post-fire ecosystem effects. This has led to descriptors like fire severity having been developed to assist with considering the long- and short-term influence of fires on ecosystems.

These metrics however, tend to focus on assessing organic matter losses after fire by either describing it qualitatively or utilising more quantitative lower fidelity approaches (e.g. satellite dNBR measurements). However, neither are able to quantitatively compare energy flux delivered by the fire with biomass loss, regrowth or ecosystems shifts.

In order to address this challenge, we have assessed the ability of charcoal to provide forensic evidence of fire behaviour across a burned area following prescribed fire or wildfire events. Here we report that measurable charcoal properties record the energy-flux delivered by a passing fireline to ecosystem components. These results are derived from instrumented field-scale wildfires in the New Jersey Pine Barrens. We propose that our approach may provide a novel quantitative fire-severity metric (ChaRoFlux) that bridges the gap between fire intensity and fire severity. We hope that with further work ChaRoFlux may enable ecosystem managers to assess and develop best practices to maintain ecosystems that have a natural requirement for fire, whilst serving the need to preserve life and infrastructure.

Keywords: fire intensity, fire severity, prescribed fire, fire behaviour, ecosystems effects

Bio: Claire Belcher is Professor of Earth-System Science and Director of the wildFIRE Lab at The University of Exeter, https://wildfire-lab.com/ Claire gained her PhD in 2005 studying linkages between asteroid impacts and wildfires. She has since become known internationally for her endeavors that cross wildfire disciplines as highlighted by her book http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0470657480.html. Her research ranges from assessing fire's role in regulating atmospheric oxygen through to undertaking instrumented field-scale wildfires; where the focus of her multi-million dollar funded lab is to develop tools for understanding fire-effects and assessing the role that fire has played in shaping ecosystems and regulating Earth-system processes.

170. Mountain Pine Beetle Effects on Wildfire Rate of Spread – the British Columbia Fire Season of 2017

Presenter: Chris Stockdale, Fire Research Scientist, Canadian Forest Service
Additional Author(s): Englefield, Peter, Physical Sciences Officer, Canadian Forest Service
McLoughlin, Neal, Wildfire Specialist, Alberta Agriculture and Forestry
Axelson, Jodi, Assistant Cooperative Extension Specialist, University of California Berkeley
Perrakis, Daniel, Wildfire Research Scientist, Canadian Forest Service
Parisien, Marc-Andre, Wildfire Research Scientist, Canadian Forest Service
Flannigan, Mike, Professor, University of Alberta

There is growing concern that mountain pine beetle (MPB) is increasing landscape-level wildfire risk, however considerable disagreement exists surrounding this issue. Some recent studies have shown that there may be short-term increases in wildfire extent, severity, and probability of ignition following MPB attack, however other studies show no change in wildfire risk. In general, previous studies have been hampered due to a paucity of fires that have burned in MPB-killed landscapes, however the 2017 wildfire season in British Columbia (BC) burned more than 1.2M ha, with much of this occurring in MPB-killed areas. Observations made by fire behaviour analysts indicate that the fires that burnt in the 2017 season were larger, spread faster, and burned more intensely than they would have in the absence of the MPB-affected fuels. These recent observations have yet to be quantified, but we can make effective use of these recent fires to advance our knowledge with regard to understanding how MPB—killed trees affect the rate of spread of fire, and how this in turn affects the relative burn probability of the landscape.
One of the main objectives is to examine the effect of MPB-killed trees on the rate of spread of wildfires, which in turn affects the size of subsequent wildfires, and the landscape burn probability. Using hotspot data from the MODIS and VIIRS satellite platforms we examined roughly 150 fires and developed methods to derive rate of spread from more than 9,000 fire spread events. To determine the influence of MPB-kill on the rate of spread, size of fires, and landscape level burn probability we related each spread event to the fuel conditions present at the time of fire. Fuel conditions were determined using BC Aerial Overview Survey data to develop a beetle-severity index that accounts for the presence/absence, level of severity, and time since attack of MPB across the landscape. These differences in rates of spread will then be used to simulate tens of thousands of fires under a broad range of weather conditions across a theoretical landscape with a mosaic of red, grey, and downed-

wood stages. This modeling will be done using the Burn-P3 model to examine the effects of the MPB epidemic on landscape-level burn probability.

Keywords: Remote sensing, VIIRS hotspots, Mountain Pine Beetle, rate of spread

Bio: Chris Stockdale conducts research on wildfire risk in western Canada. He has a bachelor degree in Biology from the University of Victoria, a Masters of Science in Forest Science from Oregon State University, and a PhD in Forest Biology and Management from the University of Alberta. He specializes in studying the relationships between fire behaviour and landscape vegetation structure.

171. Determining Burnability: Predicting the Achievement and Coverage of Burns Intended for Fuel Management

Presenter: Thomas Duff, Research Fellow, University of Melbourne
Additional Author(s): Cawson, J, Research Fellow, University of Melbourne
Penman, T, Associate Professor, University of Melbourne

Prescribed burning is a key practice used to mitigate wildfire risk. In many localities, the configurations of burns are strategically planned in order to optimise risk reduction. However, an assumption of such optimisation is that burns are completed as planned. In practice, not all burns that are scheduled will be completed, and when a burn is completed, not all the nominated area will be successfully burnt. To better understand the realised achievability and burnability of strategic burn plans, we undertook a quantitative analysis of prescribed burn outcomes in South Eastern Australia that occurred between June 1, 2010 and June 30, 2016.
We investigated the likelihood of burns being completed, and for those completed, the patterns of burnt area relative to the total area nominated on the burn plan. We found that on average 29.6% of prescribed burns scheduled were cancelled without being burnt. Within burns that were completed, the proportion of the proposed burn area that was actually burnt was highly variable and skewed to the left, (mean =74%, median 84%). GAM Regression analysis determined that the likelihood of part of a proposed burn being burnt but was in-part a function of vegetation type, topography, burn size and climate. Models were developed that could explain 31% of the deviance in burn coverage, and could predict the likelihood of any point within a burn being burnt with 70% accuracy. The model could identify predict parts of the landscape likely to be unburnable (e.g. wet gullies), but could not account for situations where parts of burns were not ignited for operational reasons.
Understanding the link between proposed burn areas and actual outcomes – burnability - is important for risk planning; using likely outcomes rather than proposed would reduce overconfidence when analysing strategies using fire simulation. The development of systems to better predict burn outcome will provided for the robust optimisation of resources for wildfire risk reduction.

Keywords: bushfire; controlled burn; fire; fuel treatment; fuel reduction; hazard; planned burn; wildfire

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

172. Determining the Probability of Impact from Wildland Fires: Santa Rosa fire case study

Presenter: Cardil Adrián, , Technosylva inc
Additional Author(s): Jones, David, Msc, Fire behavior analyst, Technosylva
Monedero, Santiago, PhD, Researcher, Technosylva
Cardil, Adrián, PhD, Researcher, Technosylva

Large and intense wildfires burn millions of hectares annually, impacting societies worldwide. Environmental, social, and economic impacts can reach catastrophic levels, particularly where human populations interact closely with natural and managed landscapes in fire prone areas. While fire professionals work to protect ecological and human resources during fire suppression, personnel are frequently challenged by the complexity of controlling wildfires in wildland urban interfaces. Protecting firefighters, citizens, homes, environmental, and economic resources is made more complex by the need to prioritize limited wildfire suppression personnel and equipment to address changing wildfire conditions. The ability to estimate the probability of a wildfire reaching an area where these resources are most vulnerable is critically important to preventing loss of human life and property, and damage to ecological and economic assets. This presentation will discuss the probabilistic fire simulation mode of the Wildfire Analyst (WFA) software; an approach to simulate fire inversely while considering uncertainties in input data. This mode can assess the time and probability that a fire will reach a vulnerable area, by simulating (n) fires with varying input data according to a potential range of deviations added by the analyst in near real-time.

Keywords:

Bio: Principal Consultant at Technosylva, providing sophisticated fire behavior analysis and management software for wildland fire. Joaquin as a Professor at the University of Leon, teaches the first class on Geotechnologies and Wildfire at the MsC in Wildfires www.masterfuegoforestal.es. He has a long experience as wildfire software architect in Europe and North America, and is the chief designer of the Wildfire Analyst™ and fiResponse™ products.

173. An Information-Based Method for Calculating Values-at-Risk and Modeling the Consequences*

Presenter: Van Miller, Professor, Central Michigan University
Additional Author(s): Herr, Vince   Ph.D. Student   University of Colorado-Denver
Kochanski, Adam   Research Scientist   University of Utah
Mandel, Jan   Professor   University of Colorado-Denver

In the middle of The Fire Continuum, there resides an often overlooked set of activities—human decisions and actions for controlling or suppressing the wildland fire (WF). [To support the 'overlooked' contention, please note: the most recent published issues of the International Journal of Wildland Fire, V26, N12, and Fire Ecology, V13, N3, have respectively, 0/6 and 0/9 articles, dealing with these activities.] Though there are numerous decisions and actions that can be included in WF control and suppression, we focus on the values-at-risk (VAR) calculation given its primacy in rational WF decision making.
The salience of the VAR calculation can be readily seen through its role within the Wildland Fire Decision Support System (WFDSS), which prescribes the requisite format for noting and justifying daily WF decisions/actions. Although one can question its underlying assumptions, we will not do so in this reported study. Its efficacy will be presumed due to its presence within the WFDSS, and its normative purpose to minimize losses will be accepted.
In order for the Incident Command Team (ICT) to make use of VAR, the economic value of assets threatened by the fire and the monetary cost of resources used to suppress it must be known.

Determination of these latter costs is straightforward, but such is not the case for the value of threatened assets. Without reliable asset values, the VAR function within WFDSS becomes meaningless and rational ICT decision making seems valueless. Our WF literature review for how to determine asset values revealed that current practice is remiss at assigning those values, particularly the value of private property. To deal with this situation, we discuss a methodology developed to study the socioeconomic impacts of the 2011 Las Conchas fire bordering on the Los Alamos National Laboratory.

The simulation methodology entails:

1) NASA-provided satellite images for detecting possible hot spots on the fire perimeter.
2) Detailed asset information from litigation claims and GIS-based property values.
3) An ICT consisting of former WF managers with decades of experience.
4) The academic research team responsible for the development of WRF-SFIRE.
5) A two-day operational exercise for WF decision making with scenarios utilizing NASA images and the initial WRF-SFIRE output as primary inputs.
6) A hypothetical scenario following the exercise that calculates the socio-economic impact of different suppression activities.

After presenting the three analyses, we conclude with a comparative discussion of the calculated VARs for each scenario.

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Keywords: Decision-Making Values-at-Risk Modeling Cost-Benefit Analysis

Bio: Van V. Miller received his B.A. in Philosophy and Political Science from the University of Kansas in 1970 and his Ph.D. in International Business in 1984 from the University of New Mexico. In addition, he earned an MBA from the University of Missouri and an M.A. from the University of New Mexico. Since 2012, his work has focused on water, forests, and wildland-fire decision making; he is a certified wildland firefighter, an active member of the Brazos Canyon Volunteer Fire Department, and a licensed Emergency Medical Responder.

174. Multidisciplinary Fire Science Research at the Sycan Marsh, Oregon

Presenter: Russell Parsons, Research Ecologist, USFS RMRS Fire Sciences Lab
Additional Author(s): Sauerbrey, Katie, Preserve Steward, The Nature Conservancy, Sycan Marsh Preserve
Vaillant, Nicole, Fire Application Specialist, USFS Ochoco National Forest
Queen, Lloyd, Director, National Center for Landscape Fire Analysis, U. Montana
Moran, Chris, Ph.D. Candidate, National Center for Landscape Fire Analysis, U. Montana
Cunningham, Matt, M.S. student, National Center for Landscape Fire Analysis, U. Montana
Grulke, Nancy, Director, USFS Western Wildlands Env. Threat Assessment Center

In October 2017, a diverse campaign of fire research was carried out in the context of management prescribed burns at the Nature Conservancy's Sycan Marsh Preserve, a relatively isolated site in south central Oregon characterized by extensive grasslands, dry ponderosa pine forests and unique wetland habitats. The overarching objective of this effort was to develop integrated and reliable fuels, weather and fire datasets for evaluation of different fire models. This broad goal required an integrated methods approach to facilitate mapping and evaluation at multiple scales. To map fuels, we integrated traditional surface fuels and overstory sampling with a mobile app-based photoload platform, drone-base spatial mapping, LiDAR and ortho imagery. Wind measurements included a large network of 10' anemometer towers and a SODAR instrument to capture the vertical wind profile in 3D. Fire measurements linked surface instruments with thermal imagery from fixed wing and drone platforms. This presentation will provide an overview of the overall experiment, present some preliminary data, and discuss future directions. As a collaborative test bed for new methods and approaches, we hope that this project will lead to improved methods in mapping fuels in 3D at landscape scales, integration of fire behavior and weather data across scales, and for evaluating models across scales and different levels of detail.

Keywords: prescribed fire, drones, photoload, fuel mapping, fire behavior

Bio: Russ Parsons is a Research Ecologist with the U.S. Forest Service's Fire Sciences Laboratory in Missoula, MT. Russ received degrees in Forestry from U.C. Berkeley in 1992 (B.S), the University of Idaho in 1999 (M.S.), and the University of Montana in 2007 (Ph.D.) His research focuses on simulation modeling at multiple time and space scales, ranging from landscapes and fire regimes to highly detailed 3-D fuel modeling at stand scales. A key theme of his work is to improve our understanding of how fuel changes alter fire behavior and the consequences of these changes for fire ecology and management.